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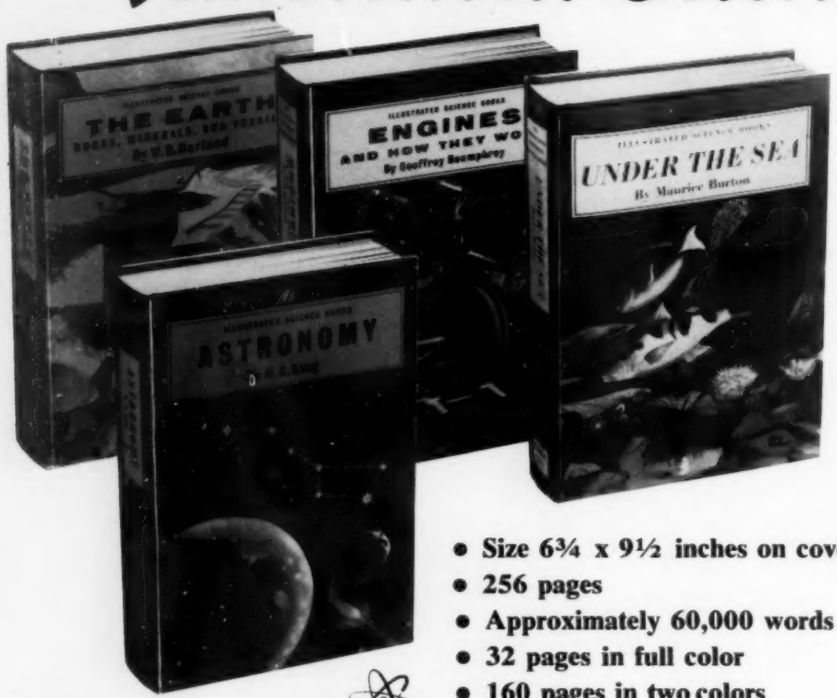

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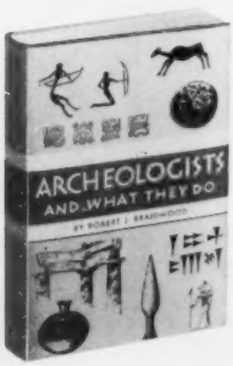

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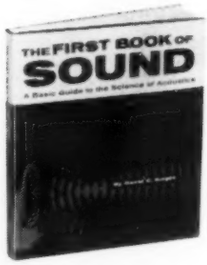

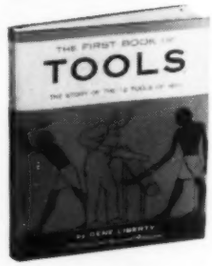

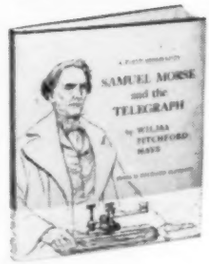

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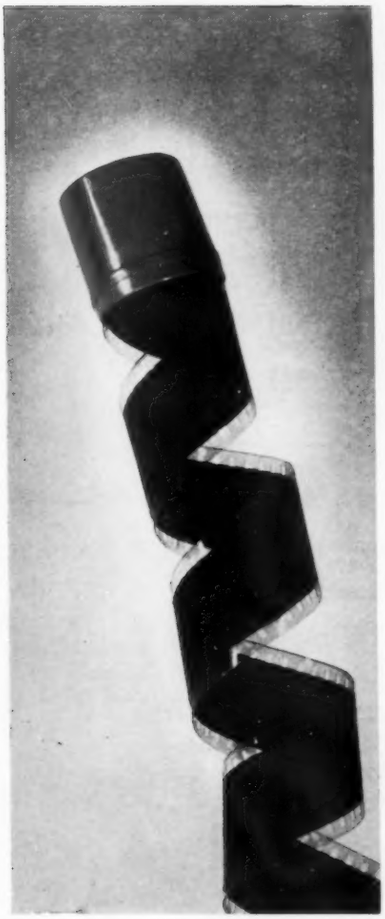

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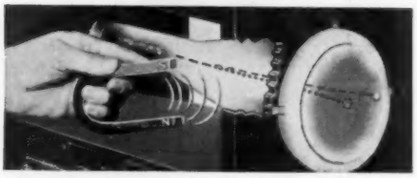

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The National Science Teachers Association is a department of the National Education Association and an affiliate of the American Association for the Advancement of Science. Established in 1895 as the NEA Department of Science Instruction and later expanded as the American Council of Science Teachers, it merged with the American Science Teachers Association and reorganized in 1944 to form the present Association.

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NEA NOTES

EDITOR'S NOTE: From time to time, we will report events and data of interest from the other NEA units in this column. Additional information on the items reported may be obtained by writing the individual groups.

Association for Supervision and Curriculum Development

The Association for Supervision and Curriculum Development (ASCD) has announced its Sixth Curriculum Research Institute. Theme of the Sixth Institute will be "New Dimensions in Learning: Aspects of Individual Differences." Co-sponsors will be ASCD and the National Institute of Mental Health. As in previous institutes, scholars from other disciplines will present "background" papers, followed by a session in which individuals and teams engaged in curriculum improvement will study the implications for education. The Eastern section of the Institute will be held December 3-7 at the Burlington Hotel, Washington, D. C. The Western section will meet April 22-26 in Denver, Colorado. Inquiries should be addressed to ASCD, 1201 Sixteenth Street, N.W., Washington 6, D. C.

"Curriculum Frontiers in the 60's" is the theme of ASCD's next Annual Conference to be held in Chicago, March 12-16, 1961. Members of this Association are concerned with all areas and all grade levels as they work for curriculum improvement. Through discussion groups, "job-alike" groups, area meetings and assemblies, the ASCD Annual Conference seeks to direct its attention to meeting the needs and concerns of individual members and participants.

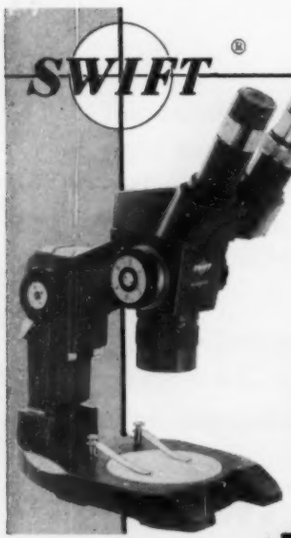
Department of Audio-Visual Instruction

"Teaching Machines: An Annotated Bibliography," by Edward B. Fry and others, has been published by DAVI as Supplement I to its journal, *AV Communication Review* (April 1960, 80p., $1.50). With more than 120 annotations, this special issue also contains the names and addresses of 12 teaching-machine manufacturers together with detailed descriptions of some 28 experimental auto-instructional devices.

National Council of Teachers of Mathematics

Beginning in October 1960, the National Council of Teachers of Mathematics will hold a series of eight regional invitational conferences in centers over the United States. The project is supported by a grant from the National Science Foundation. Frank B. Allen, a member of NCTM's board of directors and chairman of the mathematics department at Lyons Township High School and Junior College, La Grange, Illinois, will be the director of the project. Each conference will be conducted by a team of three consultants—a mathematician, a classroom teacher, and a person from the field of teacher training or supervision. Purpose of the conference is to provide selected mathematics supervisors and administrators with the information and orientation they need to provide leadership in establishing new and improved mathematics programs in their local schools. The project is being advised and directed by a steering committee of representative mathematicians and mathematics educators.

For further information about the conference, address the National Council of Teachers of Mathematics, 1201 Sixteenth Street, N. W., Washington 6, D. C.



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Editor's Note: With the beginning of a serious year ahead of us, we thought you might enjoy some lighter moments by sharing some of the verse submitted by our members.

The following contains an idea which is being overlooked in our massed efforts for better equipment, higher salaries, and stepped-up learning. The jargon used by educators cannot give it to a teacher, but for the teacher who has it, the students will drive themselves. I submit it for your column.

> Though I possess the knowledge of Seaborg and Pauling and can speak with eloquence and persuasion, and have not the understanding of my students, I am not a science teacher. And if I know my pupils' IQ's but do not try to learn their present interests and levels of comprehension, it profits me nothing. Though I arrive at school an hour ahead of my pupils and remain two hours after their departure but talk over their heads, it profits them nothing. Though my laboratory sparkle with shining glassware and my equipment increase fifty-fold through the NDEA but my students possess no desire to use it, the materials will corrode and rust away. Though my salary be increased so that my income tax be as great as my entire wage is now, but I still do not spark the enthusiasm of my pupils, I am not worthy of the pay.

A teacher builds on his pupils' previous knowledge; a teacher uses words his pupils can understand; a teacher inspires a pupil to study beyond his daily assignment; a teacher sells his subject, not himself; a teacher is just and mature in his decisions and humble, for he knows his own limitations; a teacher rejoices in the success of his pupils.

And so in a teacher one must find knowledge, dedication, and understanding, but the greatest of these is understanding.

ETHEL KURTZ
Mayme S. Waggener High School
Louisville, Kentucky

Grading: A Soliloquy in B Minus

To average or to cumulate, that is the question
Whether 'tis nobler in the mind to record
The average of the work done each quarter,
Or to take the results of each week's toil
And by adding cumulate them? To grade: To mark:
Ever more: and by a card to say we send
The efforts and the thousand natural questions
That child is heir to—'tis a consummation
Devoutly to be wish'd. To grade: To mark:
To average: perchance to cumulate: Ay, there's the rub:
For if the grade's to follow rules laid down,
When we have marked the second quarter space,
Must give us pause: there to reflect
That grade which represents the quality
Of work the child can do in that subject.
'Tis so, for not the highest reach
Nor yet the lowest depth need it relay.
But just the aptitude in that study
So that the home will know the mark to be
The pupil's average grade.

SAM S. BLANC
Gove Junior High School
Denver, Colorado

We would like to commend you and your organization for the excellent job that you have done in the development of materials for use of both teachers and administrators. All of the members of our science and mathematics staff have responded enthusiastically to the publications which your Association has prepared. This is one concrete way of positively affecting the actual teaching of youngsters.

JOHN OWENS
Roslyn Public Schools
Roslyn, New York

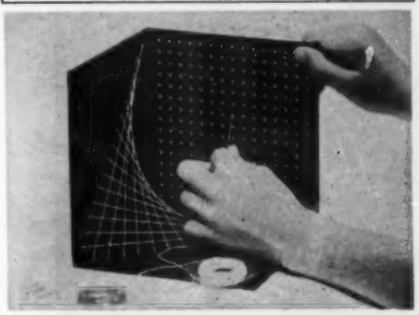
THIS MONTH'S COVER . . .

What are the problems and tasks that confront the school systems of American educational enterprise? How does science education relate to all aspects of daily living in our modern world? Who are those that must take leadership—teacher, educator, or layman?

An interpretation is given in our lead article of the selection of processes needed in the realization of present-day demands and objectives. The improvement of any instructional program is time-consuming and exacting, but it is not a new problem. As we face up to the task of improving science instruction—how will we overcome the barriers? What are the priorities? Who will establish the goals? How will we solve the problems?

If the interpretations of Dr. Schwab stimulate you to offer solutions or proposals, we invite you to share them with other readers by a letter to the Editor.

"Portable Laboratories" for the Classroom



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Enquiry, the Science Tea

THE problem now facing teachers of science is no reblooming of a perennial. It is a mutant—new in so great a degree as to amount to a difference in kind.

This problem stems from two roots: one, a national need of high and urgent priority; the other, a change in the character of science itself. The urgent national need is for a rebuilding of American brainpower and its popular support, a capital we have spent well but replenished little over the past forty years. The change in science is its transformation from a literal-minded empiricism to a complex in which conceptual invention plays a vast role, determining the facts we seek and constantly redetermining the meaning we confer upon these facts. Let us look first at the change in science, for this change determines the kind of brainpower and the kind of popular understanding of it which the nation requires.

Sixty years ago, it was still possible to defend the view that science was a matter only of seeking the facts of nature and reporting what one saw. All else was ignored or condemned as "metaphysical." Scientific knowledge and permanent knowledge were treated as synonymous. Science was supposed to grow only by accretion and by added decimal points. New facts were added to older ones. Older ones were rendered more precise. But on the whole, science was conceived as a collection of separate statements so nearly independent of one another that no new one could send an older one to oblivion.

Under such a dispensation, only one conspicuous criterion determined whether a statement were truly scientific: Was it reliable? Reliability meant that the data which grounded the statement could be seen by others with appropriate precision and accuracy. If a statement met this standard, it was inscribed forever on the scroll of science.

The view which now controls the advance of enquiry differs from the old in only one major respect: it imposes an additional criterion. But this additional criterion is so far-reaching in its effect that it has given rise to a new dimension, a new characteristic of scientific knowledge—radical and progressive revision.

Standard of Validity

Let us call the additional criterion *validity*. The standard of validity asks that the data we use shall be not only reliable but *representative*. It asks that they reflect as much of the richness and complexity of the subject matter as is possible. We are no longer content with just any discoverable reliable truths about a congeries of items. We want truth about them which will be organized and "telling," which will give us a full and satisfying account of the subject in question. We are no longer happy, for example, with psychological research which studies only the learning of separate scraps of material or one which minimizes the history, the likes and dislikes, the personality, and the motivations of the learner. Rather, we want an account of learning which places learning in the whole rich context which affects it.

The demand for growth in validity leads to the revisionary character of science. Early investigations in a field use guiding concepts of the subject matter which are necessarily simple. Their use unfolds knowledge of the subject and leads to refinement and invention of techniques. This knowledge lets us envisage new and more complex conceptions. The growth of technique enables us to put these new conceptions into practice as guides of a new research. And with each such change of conceptual system, the older knowledge gained by use of the older principles sinks into oblivion. The facts embodied are salvaged, reordered, and reused, but the knowledge which for-

merly embodied these facts is replaced almost entirely.

Thus, the cliche that science is cumulative refers to *development* of knowledge, not to more increase in amount. Each new fact discovered through the guidance of new conceptions throws a new light, a new meaning, on facts already known. The old meanings, expressed in the older statements of the science, are no longer adequate. They are replaced by new knowledge which is more comprehensive, more complete, or more discriminating than the old.

At the present tempo of research in the Western World, I would estimate the duration of a revisionary cycle in a median science to be on the order of fifteen years. Thus, a body of knowledge acquired in the conventional way by a graduate of 1960 is likely to be largely inadequate by 1968 and as obsolete as notions of body humors, the ether, or the impenetrable atom by 1975.

The gross implication of this revisionary process for science education is frighteningly obvious. It means that the notion of coverage, of conveying the current knowledge of a field, which was once the essence of science teaching, is called into question. It means that *expertise,* authoritative possession of a body of knowledge about a subject matter, is no longer enough to qualify men as the best teachers of science. It means that the education of the science teacher must be something more than, perhaps something quite different from, the inculcation of conclusions and training in ways and means to pass them on. It means that time-hallowed instruments of instruction—the lecture which aims to be simple, clear, and unequivocal; the textbook which aims to eliminate doubt, uncertainty, and difficulty; the test which aims primarily to discover what the student knows and how he applies what he knows about a subject—these will be inadequate or even inappropriate for much science teaching.

We shall return to these matters more positively and more discriminatingly later. For the moment let the general alarm suffice while we turn to the second massive determinant of our problem, the urgent national need.

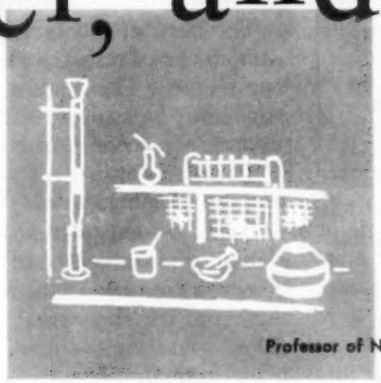
This national need to rebuild our capital of trained, scientific manpower and its popular understanding exist because both have fallen to levels dangerously low. In the past fifty years we have exploited the capital resources of science with great success and ingenuity. This exploitation has been of two kinds. On the one hand, it has been technological exploitation—the application of established scientific formulations to the production of material needs and luxuries.

What is Enquiry?

The second exploitation is less commonly distinguished from the whole body of science. It consists of the pursuit of *stable* scientific enquiry at the expense of *fluid* enquiry. By stable enquiry, I mean researches which receive their conceptual principles from others and treat these principles as matters of fact, not matters for test. If organ and function are current conceptions, the stable researcher is concerned with discovering the function of this organ, then that, then another. If the conception of the gene is current, the investigator sets out to discover what genes are involved in first one, or another inherited characteristic.

In each stable enquiry, the investigator's eye is on the immediate outcome, the filling-in of a particular blank place in knowledge. The blank place itself and the way to go about filling it are conferred by the principles of enquiry. The stable enquirer thus uses his principles as means of enquiry, but not as objects to be enquired into. They define his problem for him and guide the patterns of experiment which

eacher, and the Educator



By JOSEPH J. SCHWAB

Professor of Natural Sciences and Education, University of Chicago, Chicago, Illinois

will solve it, but they are not treated as problems in themselves.

In fluid enquiry, on the other hand, the aim of research is to test the principles and ultimately to revise or invent replacements for them. The goal is not the immediate knowledge of the subject which use of the principles may lead to, but discovery of their limitations as intellectual tools of long-term programs of stable research.

These two activities—technology and stable enquiry—are enormously valuable in themselves. But in the United States in the past fifty years we have pursued them in such a way that they have become an uncompensated disbursement of capital.

Two conditions make such an outcome possible. In the first place, both stable enquiry and technology require the prior existence of their intellectual foundations. Technology must have its body of scientific theory as a base. Stable enquiry must have its principles of enquiry as a base. Moreover, these bases wear out. It is quite possible to exhaust the technological possibilities of a given body of scientific knowledge. Each technical development generates new needs and wants, and eventually, these reach such a level of novelty that they can no longer be served through the existing body of knowledge. In the same way, stable enquiry exhausts its principles. Ultimately, all the important questions which they permit are asked and satisfactorily answered, and the answers exhibit new vistas of ignorance and complexity which the principles are unable to encompass.

If, during such a development long extended, we also maximize the social, monetary, and psychological rewards for technology and stable enquiry, the consequence is obvious. Most—perhaps, nearly all—of our energetic and able are attracted to these fields. Few will have turned to the fluid enquiry which could have refreshed and replenished the bases of technics and stable enquiry. Withdrawal will have far exceeded deposits. This can go so far that not one person in ten thousand attracted toward the field of science even knows that such a thing as fluid enquiry exists.

Until recently, we could compensate in part for this neglect of fluid enquiry by borrowing intellectual capital. England, France, Germany, and Scandinavia trained their potential scientists with quite a different emphasis, one which assigned a higher place to fluid enquiry. They meted out rewards with a commensurate difference of emphasis. Hence, they undertook numerous tests of principles and developed new conceptual frameworks. These entered the stream of intellectual commerce and were freely available to us.

This is no longer the case. For reasons I shall not discuss, the stream has dwindled and its course has been dammed or impeded. We are beginning to be alone. We are grown up now and must learn to take care of ourselves. Meanwhile, Russia has grown big, not only in technology but in the pursuit of fluid enquiry. Since the stream between them and us most assuredly does not flow freely, we are not only alone, we are hard pressed. It is now time and past time for us to make our own way.

NOTE: This article is drawn from the published report "Current Concerns and Issues in Science Education," published by the Association for the Education of Teachers in Science, an NSTA Section, and delivered at the NSTA Convention in Kansas City, Missouri, March 30, 1960. Permission has been given by AETS and the author for publication. It has been re-edited by the author for TST.

We must deal with one more point before passing on to problems of education proper. Just as we have emphasized stable enquiry and technology as a whole at the expense of fluid enquiry, so we have created a similar imbalance within technology. We have prepared a great many conventional engineers, too few original ones. Meanwhile, our engineering problems have gone through the ceiling of novelty with which conventional engineering can cope. The exigent problems of propulsion and guidance of missiles, of space exploration, space medicine, and biology cry out for new and original principles of engineering.

Here, then, is the situation which science education is called on to face. We must so recast the internal structure and content of our courses, our aims and practices, that our teaching will redress this balance. We are asked to discover, select, motivate, and launch an increasingly large group of fluid enquirers and original engineers —and a nonscience public which understands the nature and consequence of the work these scientists do.

To develop the consequences for educational policy which these matters portend, let us examine what our teachers will need to teach. This will show what teachers need to know.

Meeting a Dual Need

What our teachers need to teach is determined, first, by the fact that our national need is a dual one. There is an urgent pressing need for an increasing number of fluid enquirers and original engineers. There is also need for a voting and supporting republic of nonscientists who understand the work which scientists do. This dual need in turn creates a dual clientele within the schools—those who are, potentially, consumers of scientific knowledge; and those whose potential interest and special competences distinguish them as possible makers of that knowledge. For these two groups, our aims will not be wholly the same. The second group will require more from us than the first.

The need of the first group is for a *valid* image of research and of scientific knowledge. This, most courses in science do *not* supply. The traditional course has been, on the whole, a literalistic treatment of science and a rhetoric of conclusions.

It has tended to treat only the outcomes, the conclusions of enquiry, divorced from the data which support them and the conceptual frames which define—and limit—their validity. And it has treated the terms of these conclusions—such notions as force, gene, kinetic energy, physiological function, biological species, and so on, as if they had the same literal standing and existence as this desk-here-now.

The result of this conclusional and literal rhetoric has been to convey a false image of science. It is seen as knowledge literally true, closed, permanent—even complete. This misleading image is further enforced by the neatness with which our courses are usually organized and expounded. We tend to provide a structure which admits of no loose ends. We minimize doubts and qualifications. We strive for exposition characterized by an artistic beginning, middle, and end.

The result of these habits has been —unintentionally, to be sure—to create a climate of opinion inimical to science. From ignorance of the limited scope and validity of scientific conceptions, students are led to expect certain behaviors of common-sense objects which simply do not occur. This breeds cynicism about science and its value, a cynicism summed up for so many of our students by a walling-off, a total alienation of the ideas of theory and practice, science and common sense.

From failure to discriminate data and conception and to understand the role of each in science, the student is led to treat conclusions as inalterable truths. When this conviction proves false five or ten years later he retreats from clarity to confusion and from confusion to generalized suspicion of scientific competence and authority.

To avoid these unintended meta-consequences of our teaching, we need to imbue our courses and exposition with the color of science *as enquiry*. We need to give the student an effective glimpse of the vicissitudes of research. He needs to see the scientist try to subjugate the complexities of nature to the limitations of available methods of research. He needs to see the readiness with which the enquirer moves to challenge the soundness of his own work and to start afresh. Most of all, the student needs to understand the *conditional* truth of scientific knowledge. Wherever possible, he needs to know the specific, concrete conditions which limit the truth and application of the bodies of knowledge he is taught.

Liberal Activities

We need to go one step further. If a student is to keep rapport with the changing face of science when he is no longer a student, he must be freed as far as possible from the need for schools and schooling. He needs to develop the competencies and the habits required to read and learn for himself. This will require us to test that most cherished fantasy of the teacher —that students truly learn only with our help. Courses will need to set off certain segments of their subject matter for mastery by the student by himself. Some parts of some examinations must be concerned to test developing competence in this regard and include, as a matter of course, the same sort of queries on matters self-learned as are used on material mastered with the help of the teacher.

Scientific literacy of this kind as an objective of the school means a great deal more than the mechanics of reading and the use of reading aids. On the intellectual side, it means search for the kinds of meanings that characterize enquiry. This requires a sensitivity to the changing formulation of problems and to their growing validity. It includes identification of new conceptions and appreciation of their role in the new enquiry. It involves the noting of the data adduced and a judgment about its adequacy. On the emotional side, scientific literacy involves a growing up, a renunciation of dependency and passivity in favor of readiness to rely on one's own resources. These competencies are a far cry from mere willingness to do the assigned, receptive ability to understand the given, and a simple appetite for acquiring facts as stated.

So much for students in general. Before we turn to the potential scientist and his additional needs, let us look at some of the materials and methods by which the curriculum can serve the needs of science as enquiry.

The laboratory is easily converted to enquiry and, happily, good work in this area has been initiated. In general, the conversion takes place by having the laboratory *lead* rather than *lag* the classroom phase of science teaching. The laboratory ceases to be a place where statements already learned are merely illustrated and where perception of phenomena takes place within the restrictive structuring of terms and concepts already laid down. It ceases, too, to be preoccupied with standardized techniques. It becomes, instead, a place where nature is seen more nearly in the raw and where things seen are used as occasions for the invention and conduct of programs of enquiry. The laboratory manual which tells the student what to do and what to expect is replaced by more permissive and open material.

Three levels of openness can be discriminated. At the simplest level, the manual can pose problems and describe ways and means by which the student can discover relations he does not already know from his books. At

a second level, problems are posed by the manual but methods as well as answers are left open. At a third level, problem, as well as answer and method, are left open: the student is confronted with the raw phenomenon —let it be even as apparently simple a thing as a pendulum. He pushes and pulls, alters first one and then another of its aspects, begins to discern a problem to be solved, then moves toward its solution.

Beside its openness, the enquiring laboratory is characterized by a second general feature: it erases the artificial distinction between classroom and the laboratory, between mind and hand. The team of students which encounters a phenomenon in the raw does more than merely pull and push, time and measure, and describe. Once alternative possibilities have presented themselves, discussion ensues. The feasibility and validity of different problems are debated. Ways and means must be discussed. Techniques are devised and criticized, assumptions uncovered and identified. Then, there must be consensus and a division of responsibilities. Finally, at the end, when research reports are written, circulated, and read by different teams, there are discrepancies to be checked or accounted for in the interest of further consensus.

All these things are part and parcel of enquiry as it actually occurs—including unresolved debates, continuing diversity of problems and methods and, above all, continuing differences in concept and interpretation.

By contrast to the laboratory, the textbook, classroom, and lecture have seen less extensive revision toward support of an enquiring curriculum.

Yet, here too, pioneering development and study are taking place. In general, the enquiring classroom is characterized by the dovetailing of two sorts of activities which, together, permit what I shall call secondary enquiry, or better, an enquiry into enquiries. On the one hand, materials are provided which afford scope for such secondary enquiry. They are reports in one form or another, not of the conclusions of research taken alone, but also of the problems, the data, and the interpretative processes by which the conclusions are reached. Wherever feasible, such materials include contrast in order to widen the scope for secondary enquiry, alternative formulations of problems, alternative experimental patterns, and debates about assumptions, principles, and interpretation.

Such materials, read or heard by the student, with or without aids from teachers, lexicons, notes, or conventional textbooks, provide the base for the second component of the enquiring classroom. This second component is discussion—discussion in a sense appropriate to scientific material and endeavor. Such discussion is concerned with the elucidation, the understanding, and the attempt at critical evaluation of the materials at hand. It is not a forum for irresponsible expression by students of their uninformed opinion on the subject. Neither is it the occasion for mere quizzing about the surface content of the readings. Rather, it treats the materials read *as reports*. Questions concern the actions, judgments, and decisions of the scientists which the book or lecture described.

Such questions normally begin with consideration of the problem posed by the enquirer—what it is, in the first place; how it was generated and made important by previous knowledge in the field; what terms and conceptions the problem involves; how these conceptions agree with or deviate from those of previous researches read by the student—and the purpose served by consistency or deviation. The question then moves on to consideration of the data involved: what data are required to solve the problem; how far the data actually sought to fulfill the requirements set by the problems; what limitations of instrumentation or knowledge necessitated constriction of the data sought. Questions then pursue the remaining phases of enquiry: how the data are interpreted; what doubts, what new and untested notions accompany the interpretation; and how the new knowledge affects earlier knowledge of the field.

Climactic Narrative

For such enquiry into enquiries, three distinct patterns of materials and methods have been devised and tested. The simplest, and the one most similar to a rhetoric of conclusions, I shall call "climactic narrative." Climactic narrative begins with description of phenomena which symbolize the field to be treated. The symbol may be a dramatic one such as the slowing of a pendulum clock transported from Paris to the tropics. With such a starting point, a problem is formulated and the narrative moves thereafter from one experiment, its results and interpretation, to another until it reaches its intended stopping place, its climax theory.

Discussion begins where the narrative ends. It might start from a review of the climax theory. If Bohr's model of the atom had been the climax, its first questions might be, "What is an orbit?" "—a shell?" or "What is h in the equation for angular momentum?"

Then discussion would move into the current of the enquiry: "Why did Bohr postulate a limited number of orbits for the electron of the hydrogen atom?" "What is the connection between Bohr's postulate and the Balmer series?" and so on through earlier and earlier contributions to the climax theory.

This pattern of materials and discussion is effective but limited. It is limited by the fact that the linear pattern of narrative tends to convey a sense of unobstructed progress toward the climax theory and tends to treat the climax theory as whole and complete. A multilinear pattern of exposition or narration overcomes these limitations.

Multilinear exposition is one which includes description of alternatives, difficulties, and doubts attendant on enquiry. Some of the alternatives taken seriously at a given time are examined in the light of their various supporting evidences. There is emphasis on the uncertainties and losses involved in choosing one over other alternatives. The inevitable dubieties and debates which attend interpretation of data can be illuminated.

With materials of this kind to work with, the scope of possible enquiry into the enquiry is much increased, and more participation by the student can be evoked. He can array the arguments in favor of one explanation as against another, express a preference (with reasons), and thus invite fruitful debate with other students who have reasoned preferences for other alternatives. Then the various emphases, reasons, evidences, oversights, and misconceptions involved in the students' debate can themselves be subjected to scrutiny. In these ways—and a number of others—multilinear exposition and the discussion it makes possible is more fruitful than climax narrative.

The third pattern of materials and methods uses actual reports of enquiries, original papers from the journals of science, as one of its materials. A coherent set of such papers is usually employed as an interlude of depth and firsthand contact with scientific reporting in connection with materials of other kinds. Thus, a study of genetics might be initiated with Mendel's original contributions and one of the papers by E. M. East on the inheritance of continuously varying characters. Thereafter, the burden might be carried by climax narrative, multilinear exposition, or traditional rhetoric of conclusions. Similarly, textbook material might introduce a study of endocrine function to be superseded by a set of actual research papers on one of the endocrine functions—the thyroid or the pancreas—and textbook study resumed thereafter.

Let these instances suffice to suggest the forms which the enquiring curriculum can take and return to the problem of the potential scientist.

Motivation and Selection

The additional problem posed by the potential scientist among our students is primarily one of appropriate motivation and selection. In the past, we have relied heavily on two criteria which are inadequate to present needs. We have sought the student who is interested by the subject matter of our science or by its technical methods and devices: living things, telescopes, electronic devices, dissection, collecting, and construction. We have also tended to seek out students whose intellectual predilection has been primarily *acquisitive*—acquisitive of facts, of technical vocabulary, of rules and formulae, and of technical know-how.

These are useful but they are not enough. Taken alone, they may identify stable enquirers and standard engineers. They provide little, however, by which the student of original mind and a bent for frontier investigation can identify himself and be attracted.

For this student, we need to provide opportunities of quite a different kind. He needs to discover that science affords an opportunity to challenge the truth of existing rules and "laws." He needs to discover in science the excitement of pursuing something that others have not yet caught. He also needs to discover whether he has the stamina for fluid enquiry and original engineering—the stamina which is necessary to sustain the burden of uncertainty and the possibility of failure which are the regular risks of frontier enterprises.

For these purposes, the potential scientist needs exposure to the most completely open and unstructured versions of the enquiring curriculum. For him, the laboratory work which specifies neither problem nor method is the appropriate one. The classroom which rests most firmly on the uncertainties, doubts, and difficulties of firsthand reports of investigation is one most likely to evoke his competence and interest. It is through the activities of invention, analysis, and critical evaluation they afford that he can participate in and be conditioned to the vicissitudes of enquiry.

We turn now to a very brief glance at the program of teacher education which would be required for an enquiring curriculum.

Much of what can be sketched in outline is already obvious. A teacher whose own study has been dogmatic and doctrinaire will be unprepared to teach science as enquiry. And a teacher whose own training has demanded, or done little to discourage acquiescence, dependency, and passivity will, in all likelihood, demand the same of her students. The first of these strictures bears mainly but not exclusively on the teacher's subject-matter training. She will need to have a substantial part of that training in the form of an enquiry into enquiry—enough of it to equip her or him with the ability to read and understand reports of enquiry. She will need to become familiar with the sorts of questions whose answers illuminate such materials. She will, herself, need to understand the ways in which invention and observation, data and conception, interpenetrate to form the growing fabric of scientific knowledge.

The second stricture, that a teacher whose training involved passivity and dependence will demand the same of her students, applies to all parts of teacher education. In her subject matter, in her training to be a teacher, and in her general education, a self-study component, a program of auto-instruction, is called for.

Such a component must be pervasive. It should be instituted in all departments of teacher education if it is to be effectively developed. If science departments alone demand it while education and humanities do not, the students will view it as a special and unreasonable imposition. If all demand it, it will become a regular part of the college culture as seen by students, and they will cease to be intimidated by it.

Conclusion

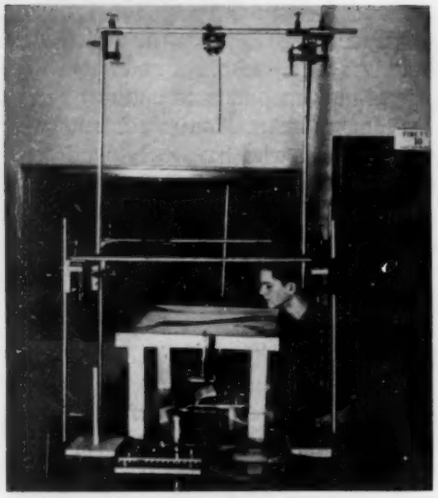
I shall close with consideration of a pressing, practical problem. How many of our high school students, how many teachers and teacher-training institutions should be involved in an enquiring approach to science? The first impulse is to view enquiry as something for very few, for the top five or ten per cent of students, teachers, and institutions. I do *not* believe this to be so.

I do believe that in the present climate of attitude and habit, it will be immediately accessible only to a few. For most students entering high school in the next year or two, it will be a shocking change of pace. For most high school students entering teacher training in the next few years, it will come as a similar shock. But this very sequence suggests what the future can hold. As a few teachers enter the high school and introduce an enquiring curriculum, more and more students will enter college who have been well conditioned to the process. They will move more numerously, at a faster and more effective pace, through teacher training and go out to accelerate the rate at which enquiry permeates the schools and returns its dividends to the colleges.

Before we turn a skeptical ear to forecast of such extensive effectiveness, let us remember what happened to the teaching of literacy. The same apparently obvious facts about educability and the same "common sense" which may now tell us that enquiry is beyond the competence of average men and women once said the same thing about teaching the ordinary man to read and write. Indeed, the first efforts at invoking literacy among persons disinherited from any expectation of it were stumbling and of scant success.

Then, however, two accelerating processes occurred. The increase of literacy spread the atmosphere of literacy, and more and more people came to expect it as a matter of course. This very expectation did away with many of the barriers which formerly made literacy difficult to learn. Meanwhile, as a literate milieu broadened among the educated, so did competence to teach literacy broaden among educators. New materials, new methods, and new insights into difficulties arose and became common property for all.

It is not too much to hope for a similar outcome to efforts to teach science as enquiry.

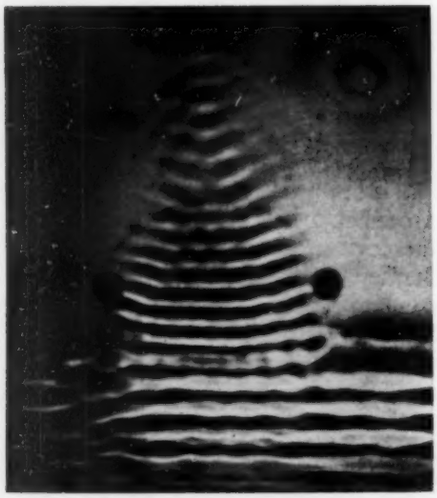


Arnold Ballanoff prepares ripple tank before photography.

PROJECT 'DARKROOM'

By HERMAN H. KIRKPATRICK

Physics Teacher, Roosevelt High School, Des Moines, Iowa



Wave phenomena will be analyzed by student Ballanoff.

Gordon Pearlman demonstrates to Curtis Lamb (left) how to photograph Doppler effect in flowing ripple tank.

This report was an entry in the 1960 STAR (Science Teacher Achievement Recognition) awards program conducted by NSTA and sponsored by the National Cancer Institute, U. S. Public Health Service.

PHOTOGRAPHY in the physics classroom has become an important part of every student project or experiment at our high school. Two years ago, the students were faced with finding a place to install a darkroom for their photographic work. Careful exploration of the entire school building revealed no suitable workroom. Continuously, we returned to the classroom and looked at the workroom now built between the laboratory and the storage room. If the work space between these areas became a darkroom, considerable interruption and inconvenience would be entailed. But foregoing these, the darkroom was set up —and no one has ever complained. Why—because project "darkroom" has contributed considerable interest and motivation for physics laboratory experiments. Secondly, the photographs developed by the students have also become effective teaching aids for the teacher. The students have even taken photographs to their homes, giving the parents an opportunity to know and learn about the particular projects undertaken in the laboratory.

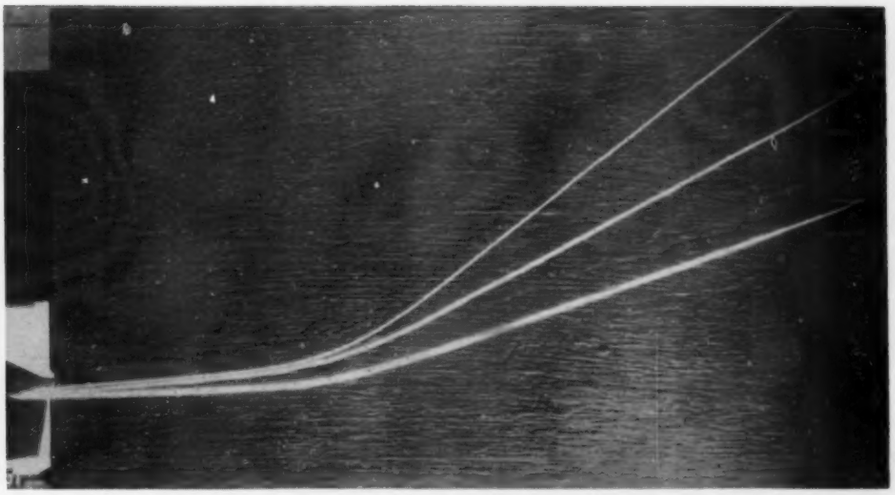
Cameras with lens peering through the whirling disks of stroboscopes are commonplace now in the laboratory along with other equipment. The light-tight window shades originally designed to facilitate the projection of films are utilized to control the light for photographic efforts. Students coming in after school to complete one of the regularly assigned experiments find themselves staying long beyond their anticipated time as they watch with fascination the procedure of the photographic experimenters illuminating their work with floodlights.

A partial listing of the topics covered by the physics students includes:

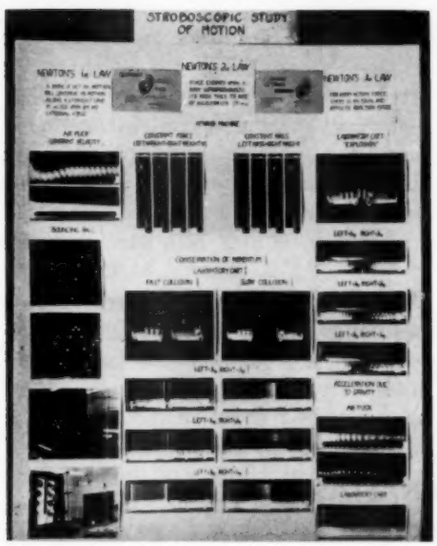
1. Photographic studies of motion—constant velocity, linear acceleration, conservation of momentum, and curved trajectories.
2. Photographic studies of the ripple tank illustrating the behavior of light waves.
3. Studies of light rays using an optical disk.
4. Studies of the magnetic fields of permanent magnets and electromagnets.
5. Color studies of the spectrum as photographed through a diffraction grating, through a slit, and through a screen.
6. Photographic records of bulletin board displays.
7. Photographs of the moon taken with a student-constructed astronomical telescope.

Generally, students begin work in the "darkroom" within six to nine weeks after the course in physics has

Pearlman's photograph of Doppler effect.



Three steel balls of various masses were each given similar initial velocities and rolled through the same magnetic field. The result is the "mass spectrograph" recorded by Vilnis Ozols.



Award-winning project of student Joseph Ball on photographic study of motion.

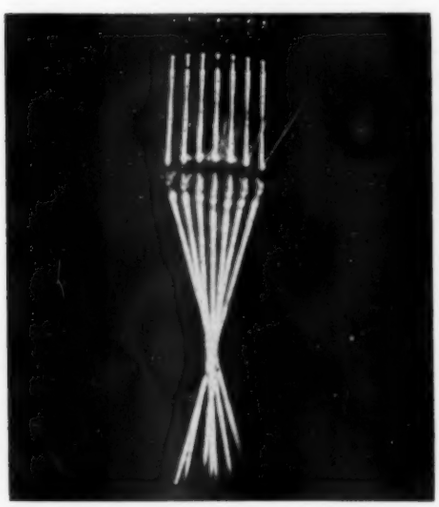
begun. Although the students commence the class with limited knowledge of the subject, they begin their investigations with the cameras confidently. After completing some photographs of a specific study, teacher and students enter into a discussion for analysis and interpretation of what the camera reveals. The results generally motivate the student to serious and careful investigations of each subject. His work becomes purposeful as he tackles it with intent and desire to discover new data to report to the class. Photographs with explanations are displayed from time to time on the bulletin board. This gives students a chance to challenge others or learn from them.

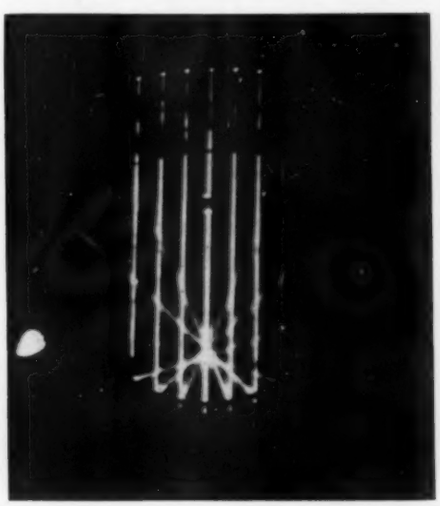
The photography work has also been beneficial for use in local science fairs and has been part of some winning science projects. In addition, the photographs become a documentary or historic source of student investigations.

The interest and motivation from our "darkroom" is far beyond any inconvenience or obstacle that might be involved as to location. If your science classroom does not yet have such a room, the photographs in this article may give you evidence of its value. Your own students may produce even more spectacular results.

EDITOR'S NOTE: The dramatic photograph on the February 1960 cover of TST was submitted by the author of this article. One of his students had photographed the magnetic field around a coil through which an electric current flows.

Light rays using the Hartl Optical Disk taken by student Pearlman.





Award winner Richard Cromwell displays photographs made with his homemade telescope.

EXPERIMENT IN ELEMENTARY SCIENCE

By NICHOLAS ANASTASIOW

Principal, De Anza Elementary School, Palo Alto, California

SCIENCE for children perhaps can best be thought of as the mastery of certain skills and knowledge that will enable students to meet the demands and challenge of the age in which we live. Science skills teach a student to observe, evaluate, select, recognize, and understand problems, and they are prerequisite to the independent judgments which students must make on problems confronting them. In addition, science has become inexorably enmeshed in the social institutions of the nation and must be studied with these institutions if we are to strengthen and enhance the large area of knowledge in social studies.

Any elementary curriculum of today must include systematic teaching of the skills and abilities thought of as science. In Palo Alto, current thinking is that approximately one-twelfth of the school day should be devoted to science instruction. This time may be spent in blocks of an hour a day over a period of three to four weeks for the basic units and forty minutes twice a week for those science units which lend support to the social studies program.

In addition to the planned program of science, incidental teaching will also occur as students' interests create questions leading to a probing of wide areas of science learning. During the daily news program of the classroom, for example, investigation and reporting on new space travel or rockets will be discussed in the upper grades while such events as a newly found butterfly will capture the attention of a primary grade. The existence of a planned science program which recognizes the desirability of a coherent pattern and sequence of learnings will not restrict the ingenuity of a teacher who can capitalize on current interests of children.

In the pre-Sputnik days of 1957, the curriculum council of the school district looked at the needs of science teaching in the curriculum and recommended a revision. Teachers from all levels, elementary and secondary principals, and science specialists from Stanford University formed the Science Steering Committee and met to determine the direction of the revision. No sooner had they started, when the Russian Sputnik blazed across the sky and paper headlines of the United States. The committee now faced two problems: the question of which direction revision should take, and the pressure of public over-emphasis during national concern and perplexity.

Specialists in local electronic and allied industries were questioned on the subjects which they thought should be included in the public school science curriculum. Members of the committee attended conventions and conferences, such as regional and national meetings of the National Science Foundation, where science problems and science curricula were discussed. In addition, a workshop was given in the spring of 1958 by Dr. Matthew Vessel of San Jose State College, California, on methods and techniques of science teaching. Books, articles, and pamphlets covering all areas of science were consulted.

Supporting research gave very little direction for the elementary school teacher. Consequently, it soon became apparent that the major decisions on the nature and revision of the elementary science curriculum would have to be made by a small committee of skilled and experienced teachers. Teachers of every grade level who knew children and how to teach them would have the most to offer as members of this research team. Those selected were also skilled in the subject matter of science.

The first task facing the committee was the choice of the pertinent and important science content for inclusion in the elementary school curriculum. Deciding what to teach and where to place it so that children could master the material and would be stimulated to explore the subject in detail became the major problem for the research team. In seeking a solution another problem was raised: What should be the goals for elementary students in science?

Other questions also demanded answers: What science knowledge do we want elementary students to possess? What skills do we want elementary students to attain? What observable abilities do we want to be able to measure?

From the multiple-source background and experience of the research team came the realization that any science program should reflect and teach the particular skills and abilities that our children need to become fully informed adults. These skills and abilities reflected the ultimate goals stated in terms of teaching objectives.

The teaching objectives cover wide areas of learning, but are expressed in specific terms that can be measured, observed, and taught to students. They range from skills in observing, classifying, predicting, and estimating to the ability to select, evaluate, and understand the written material of science. They include:

1. Skill in observing differences and similarities in plants and animals, rocks and minerals, compounds and mixtures, planets and stars, and weather and climate.
2. Skill in classifying by structure, function, and habits.
3. Skill in estimating and measuring.
4. Skill in using science equipment and materials.
5. Ability to use the written material of science.
6. Ability to select and evaluate information.
7. Skill in using natural resources and products of man.
8. Ability to understand the principles of science and the laws of nature.
9. Ability to understand the contribution of men of science.
10. Ability to use the problem-solving method.
11. Ability to understand the needs of living things.
12. Skill in recognizing the aesthetic aspects of science.

Following the identification of these skills and abilities came the problem of organizing the curriculum into units of work at the appropriate grades. It was recognized that students cannot achieve skills without having the subject matter carefully organized. The program was then packaged into units that were considered appropriate in terms of the child's age, grade, and other areas of learning planned in that grade.

Science Units by Grades

Kindergarten:
All science areas are introduced.

First Grade:
Animals—classification and adaptation (Basic Unit).
Simple machines (Home Unit).

Second Grade:
Plants (Farm Unit).
Animals (Farm Unit).
Communication (Postal, Fireman, and Newspaper).

Third Grade:
Weather (Basic Unit).
Animals and Plants of the Desert (Southwest Indians).
Animals and Plants of the Seashore (Bay Area).
Simple machines (Bay Area).

Fourth Grade:
California Community of Nature (Basic Unit).
Light, Sound, and Heat (Basic Unit).

Fifth Grade:
Astronomy (Basic Unit).
Physical Geography (Basic Unit).

Sixth Grade:
The Earth (Geology) (Basic Unit).
Nature of Matter (Magnetism and Electricity) (Basic Unit).
Aviation (Aeronautics).

**Second/Third Grade:*
Prehistoric Animals (Basic Unit).

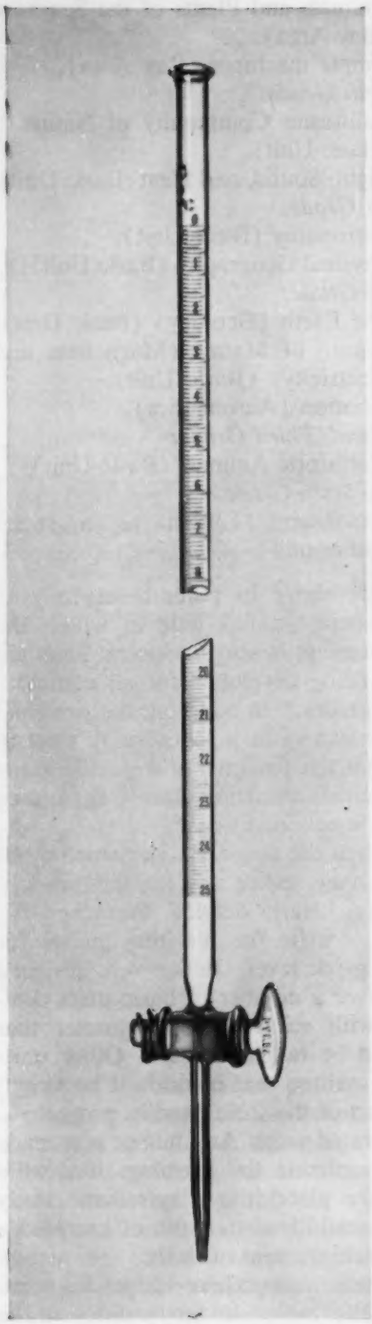
Fifth/Sixth Grade:
Petroleum (Taught as a social studies unit).

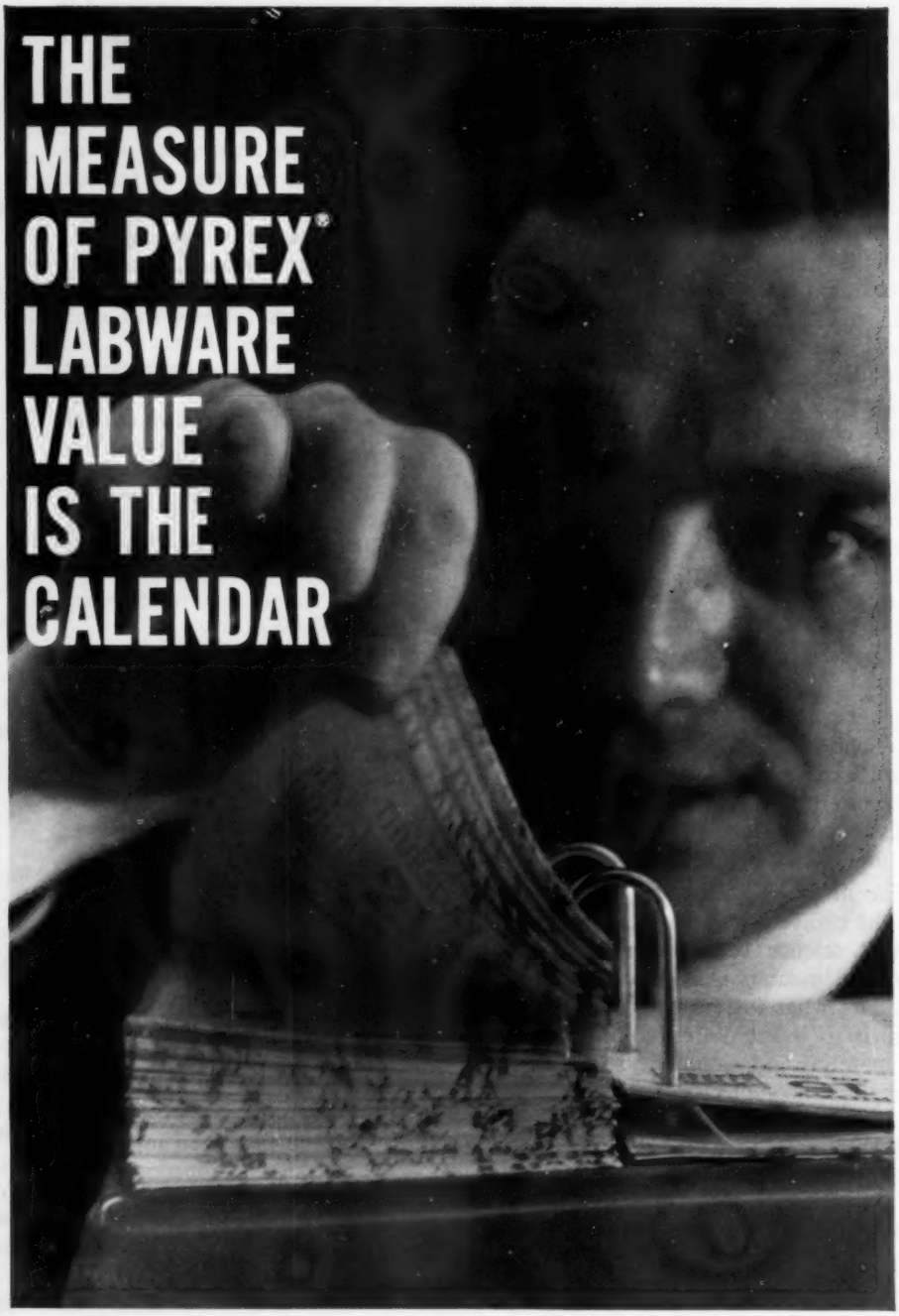
Words above in parentheses indicate the social studies unit in which the science unit is taught. Special units are also being developed for all combination grades.* In addition, the principal and teachers in a school may elect to present science units of a specific grade in their combination classes, depending upon local conditions.

When the scope and sequence problems were settled and the ultimate objectives clearly defined, the group began to write the teaching guides for each grade level. Guides were designed to cover a number of basic units dealing with science subject matter that would be taught as such. Other units were written that could best be taught as part of the social studies program—integrated units. An attempt was made to coordinate the learnings that were to take place into a systematic study that would lead to depth of knowledge and achievement of skills.

These comprehensive guides contain the major understandings to be learned—facts, concepts, and principles—the specific books, films, demonstrations, and background material.

After the guides were written, teachers had to be trained in their use. Workshops were held during 1957-58 to provide teachers with general science background information. These workshops also gave information regarding materials, demonstrations, and general presentation. During the summer of 1958 an experimental summer school was conducted at which many new ideas and procedures were tested in grades three through six.





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In October 1959, a general meeting was held at each grade level. At this time the authors of each guide presented their work, emphasizing the major objectives, demonstrations, books, and techniques for teaching the particular unit. At three workshops for each grade level scheduled during 1959-60, also conducted by the guide authors, attention was given to problems arising in the teaching of the guides. In addition, an extension course from San Jose State College on general science curriculum emphasized the major substantive areas of the guide.

Under the National Defense Education Act, Public Law 864, Palo Alto was granted district requests for matching funds and secured the equipment necessary to conduct the new science program. Additional requests have been made for recommended equipment. Samples of equipment that can be made inexpensively are also available with construction directions for teachers.

Eventually we hope that each teacher will have available in his classroom a kit of science equipment which will be appropriate for each guide taught at that grade level.

With the curriculum revised, the guides in the classroom, and the teachers indoctrinated, one might ask whether all of our children will know the difference between such elementary scientific terms as "hibernate" and "estivate," "concave" and "convex," "electron" and "proton." The likely answer is that most of them will. Even more important, they should possess such simple skills as observing phenomena and understanding what are observed. Furthermore, boys and girls in Palo Alto should possess the necessary method and approach for seeking out the appropriate source materials for answering such questions.

Even though far-reaching strides have been made in revision of the science curriculum, the district clearly recognizes that in the field of science—as in every other field—change is the order of the day. As new advances are made, district planners anticipate that the new science program will be sufficiently flexible to incorporate those changes in the curriculum which are in line with the best scientific thinking and which are desirable in the teaching of our children.

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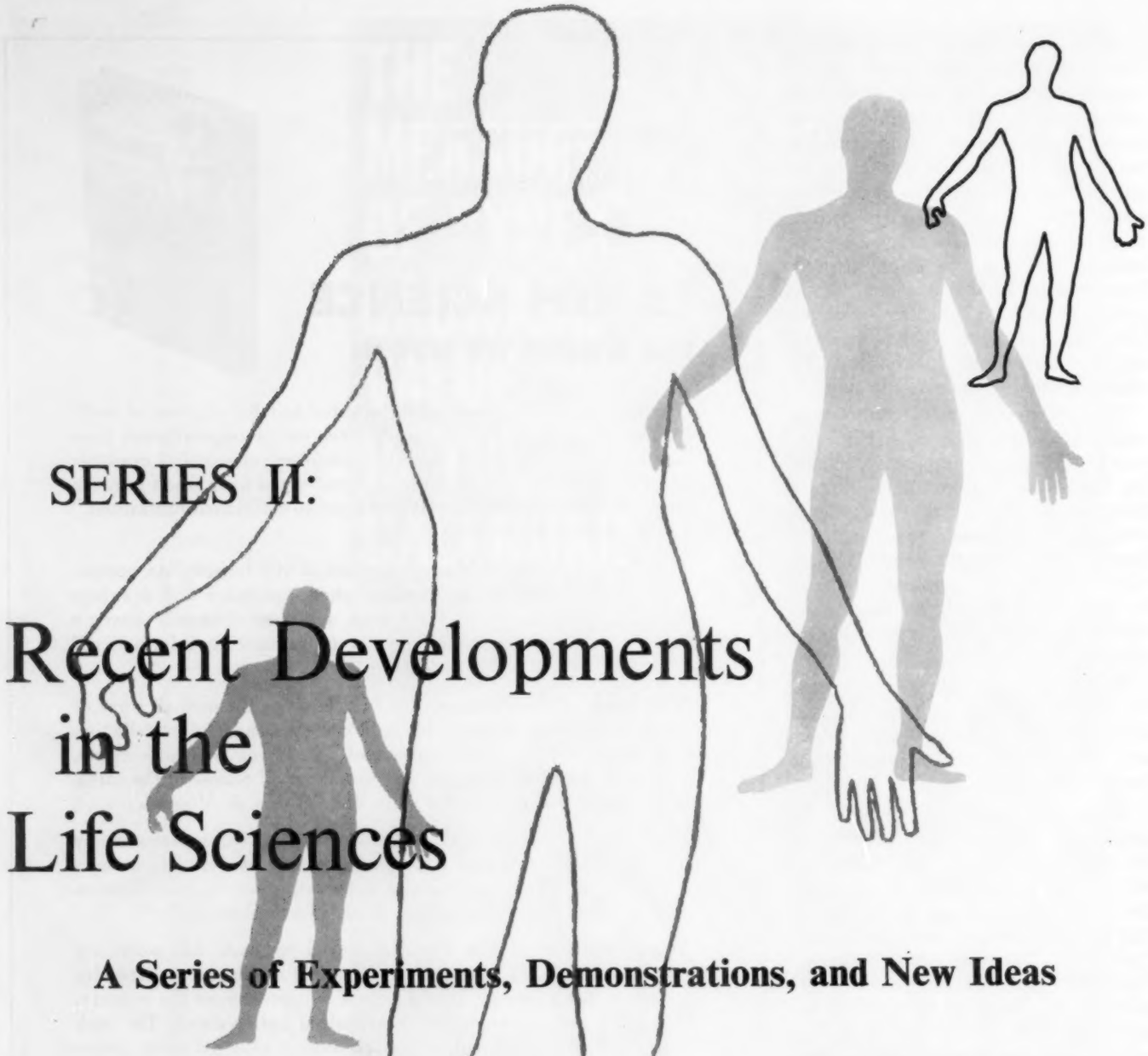


SERIES II:

Recent Developments in the Life Sciences

A Series of Experiments, Demonstrations, and New Ideas

Part A: Cancer Research

THE National Cancer Institute conducted the Second* Science Demonstration Conference for high school teachers of the Washington and surrounding region early last fall. The program was conducted by the National Cancer Institute and National Institute of Arthritis and Metabolic Diseases (Bethesda, Maryland) in collaboration with NSTA and the U. S. Office of Education.

Laboratory demonstrations in the life sciences were held to bring the teachers up to date on the latest advances in cancer research. These demonstrations were planned to enable the science teachers to view recent work and procedures by working scientists in order to reproduce similar experiences in school laboratories. The areas covered were endocrinology, viruses, metabolism, genetics, enzymes, isotope tracers, chromatography, and electron microscopy.

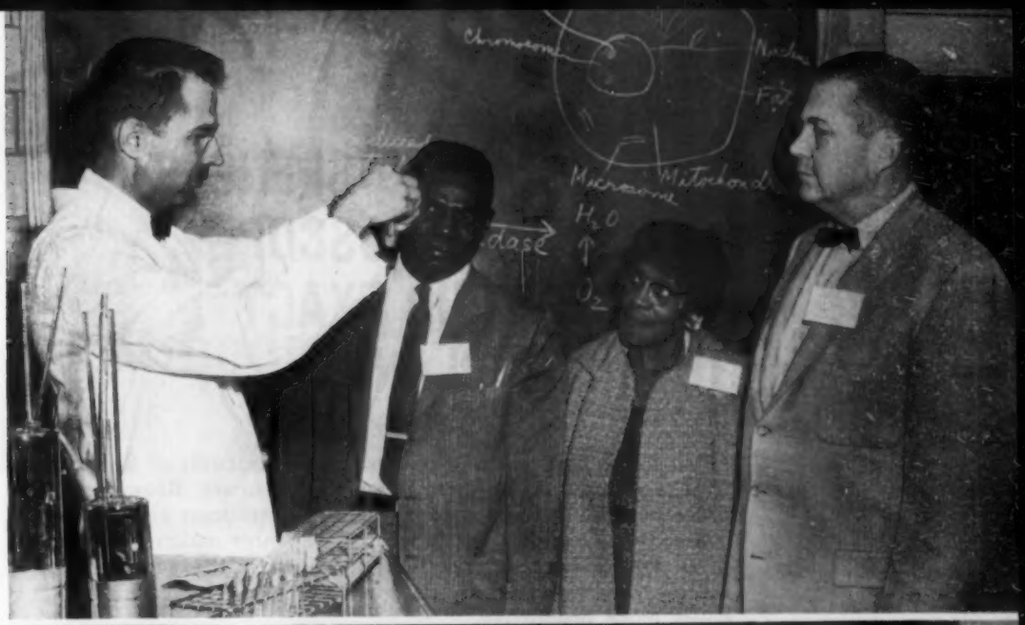
Selections have been made from the reports given at the conference, and the chosen articles will be published in our journal in two parts. Part A, Cancer Research, is treated in this issue in the four articles which follow.

Part B, Metabolic Diseases, will be covered in the December issue of *TST*.

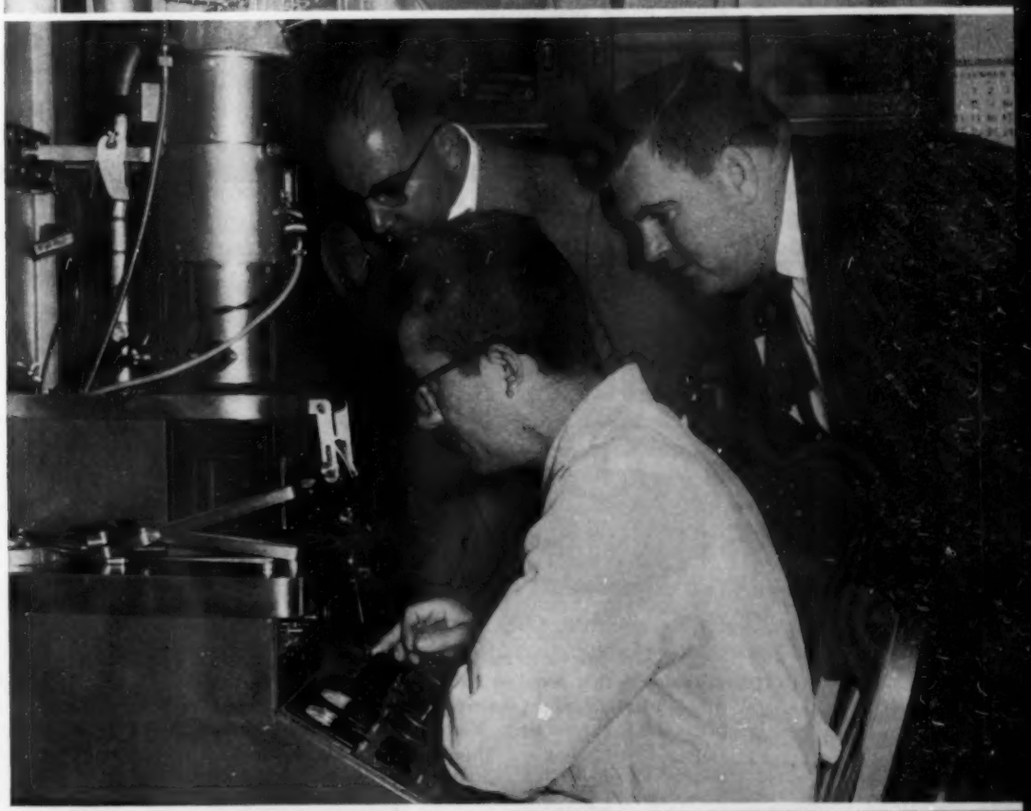
The demonstrations presented throughout the series are identified with the work of actual research and techniques being used by present-day scientists. The contribution of the scientists and professional staff in providing the science teachers with these interesting experiences serves to bring added stimulus and knowledge to the science curricula.

We acknowledge and appreciate the cooperation of the sponsoring groups and scientists who worked to make this conference so beneficial and prepared the material for the series. *Editors.*

***NOTE: The first conference on experiments in the life sciences was held in 1955. The results were reported as Series I in the March, April, and May issues of The Science Teacher, Volume 23, 1956.**



Walter C. Schneider (Laboratory of Biology, NCI) demonstrates the isolation of mitochondria, components of the cell cytoplasm which are smaller than nuclei and larger than submicroscopic particles.



Teachers watch Bolivar J. Lloyd, Jr. (Laboratory of Physiology, NCI) as he demonstrates the electron microscope which produces magnifications heretofore impossible with the light microscope or even with the ultraviolet microscope. The electron microscope is an especially valuable tool in the study of viruses. By means of this microscope, viruses can be seen within the host cells, and the cytology and pathology of the individual cells can then be studied in relation to infecting viruses.

Methods and procedures for experiments in cancer metabolism and chemotherapy suitable for high school science classes are explained by Mark W. Woods (Laboratory of Biochemistry, NCI).

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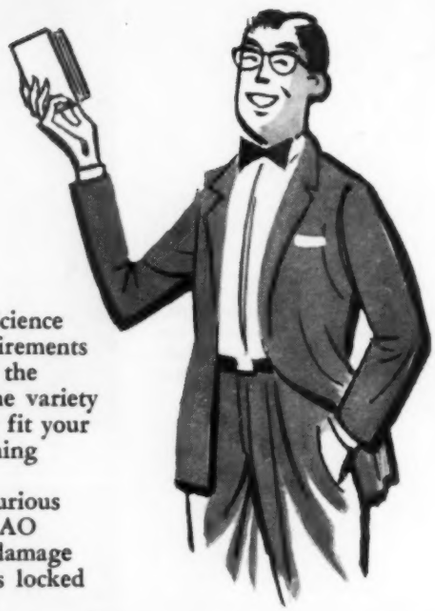

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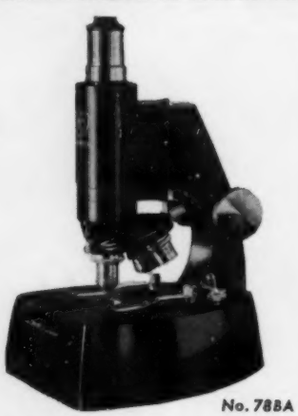

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Plasma Cells and the Production of Antibodies

By ROSS C. MacCARDLE

Laboratory of Pathology, U. S. National Cancer Institute

UPON recovery from certain infectious diseases, the body sometimes becomes less liable to reinfection by the same type of microbe. This increased resistance, called "acquired immunity," is often associated with the appearance in the blood stream of a substance which combines with the infective organism or with the toxin it produces. The first clear evidence of this was obtained in 1890 by von Behring and Kitasato who showed that the sera of animals which received repeated injections of small amounts of tetanus or diphtheria toxins had acquired the property of neutralizing these toxins. Substances that stimulate the formation of antibodies are called *antigens*. The substance that appears in the body fluids as a consequence of introduction of the antigen into the body, and which reacts specifically to neutralize the antigens, is called an *antibody*.

By 1910, antibodies were known to be associated with the globulin fraction of serum globulin protein. The proteins of the plasma can be divided into three fractions: albumin, globulin, and fibrinogen. The globulin can be separated into three fractions by electrophoresis: alpha globulin, beta globulin, and gamma globulin, with isoelectric points of 5.1, 5.6, and 6.0 pH, respectively. It is questionable whether these fractions are distinct chemical entities. Gamma globulin is intimately associated with antibody production. More refined chromatography has shown normal gamma globulin to consist of several complex fractions. One of these normal gamma globulins corresponds to what is called "myeloma globulin," which is produced in excess quantity in the serum of individuals having tumors called multiple myelomata—fatal tumors composed of plasma cells that invade the bone marrow and erode the bones. This so-called abnormal myeloma globulin may possibly be a normal gamma globulin merely produced in excessive amount, or abnormal gamma globulin.

Antibodies in man and in rabbit appear to be indistinguishable from normal gamma globulin.

Characteristics of Plasma Cells

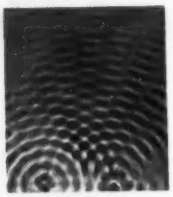
Widespread production of plasma cells occurs in human beings suffering multiple myeloma, and the increase in plasma cells is associated with production of excess serum globulin in this disease. The mature plasma cell is a round or oval cell with basophilic cytoplasm that occurs chiefly in lymphatic tissue. Plasma cells are scarce under normal physiological conditions but are increased greatly in number in chronic inflammation. The plasma cell contains a juxtanuclear *'hof'* of clear pale cytoplasm, representing the centrosome surrounded by the Golgi apparatus, and an eccentrically situated nucleus that is frequently bilobular. In some cells more advanced in maturation, the chromatin is clotted into short rods dispersed in the peripheral nucleoplasm against the nuclear membrane, as though the central nucleoplasm had discharged these clots from itself. This often gives the appearance of a cartwheel with the hub-ends of the spokes hanging free in a hubless center. On the other hand, at the surface of the nucleus, each clump of chromatin seems to be closely associated with a knot of perinuclear cytoplasm rich in ribonucleic acid, as though some nucleocytoplasmic action were in process. No mitotic figure has been found in an identifiable plasma cell since the juxtanuclear *'hof'* by which the plasma cell is detectable does not appear in a mitotically dividing cell.

Hence, it is indicated that once the precursor of the plasma cell acquires the structural features by which it can be identified as a plasma cell, it loses the capacity to divide by mitosis. Indeed, the fate of the highly mature plasma cell seems to be that it is disintegrated as the result of accumulation of excess cytoplasmic material. This may be the mechanism by which the plasma cell discharges its manufactured products into the body fluids.

Cellular Origin of Antibodies

Lymphocytic Origin: It is possible that many different tissues which encounter antigen may respond by producing antibodies. Ehrich and Harris in 1945 claimed that antibodies are produced in small lymphocytes. However, each plasma cell may be derived from a small lymphocyte, producing antibodies (globulins) as it matures and finally degenerates. Antibodies are produced in great abundance in spleen and lymph nodes. On the other hand, the plasma cell may develop independently from an undifferentiated mesenchymal cell.

Ehrich and Harris proposed the theory that the reticuloendothelial system picks up an *antigen,* makes it soluble, and passes it to the lymph nodes and thence to the small lymphocytes. These cells then manufacture an antibody as part of their synthesis of cell proteins. This is based on the highly debatable assumption that the



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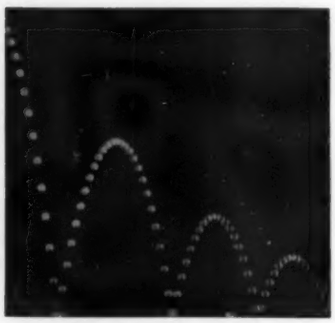

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plasma cell derives from a lymphocyte. Adrenal cortical hormones cause dissolution of the cytoplasm of lymphocytes, and the antibody thus liberated produces a rise in serum antibodies (globulins), i.e., hyperglobulinemia. It has been experimentally established that administration of adrenal cortical hormones causes a precipitous fall in the number of circulating lymphocytes and stimulation of lymphatic tissue to form new ones. The rate of mitosis is high in germinal centers of lymph nodes of mice given large doses of cortisone, and it is here that plasma cells seem to appear first following administration of an antigen.

Plasma Cell Origin: Bing (2)* was the first to suggest that the plasma cell may form serum globulins (antibodies), such as gamma globulin. This is not to say, however, that all antibodies are formed in plasma cells. Ten years ago, Fagraeus (6) immunized rabbits intravenously with a variety of antigens, and then studied the spleen and lymph nodes histologically. With the first appearance of serum antibodies, plasma cells in the spleen and lymph nodes began to increase in number. As the antibodies' titre rose, the number of plasma cells increased. Researcher Fagraeus thought that these plasma cells developed from the reticuloendothelial cells by a process of maturation. She found the plasma cells to be rich in cytoplasmic ribonucleoproteins.

Prior to birth and for variable short periods after birth, animals possess no detectable plasma cells in their tissues. They do have serum antibodies, however, derived probably from the maternal blood. The fetus and newborn have little or no resistance of their own to infection, although they are highly resistant by virtue of the maternal antibodies. It is not until eight or ten days after birth that the mouse begins to develop its own plasma cells in lymph nodes, spleen, and to some extent in the mesenteries and bone marrow. The time at which they begin to produce antibodies is unknown. In senile mice that are weak and moribund, the wall of the intestine is speckled with peculiar nodes of tissue. Upon microscopic examination, these nodes are seen to consist of dense tissue composed of plasma cells.

*See references.

The most direct evidence to show that plasma cells produce antibodies was described by Coons *et al.,* (4) who were able to identify cells containing antibody by use of fluorescent antibody. They found the antibody to be located in plasma cells of the spleen, lymph nodes, and submucosa of the ileum.

The evidence from different methods suggests that the maturing plasma cell is responsible for the active production of antibody. The origin of the plasma cell, however, is obscure.

Agammaglobulinemia

Failure to Form Gamma Globulin: In 1952, Bruton studied a young boy who in the first four years of his life had eighteen severe infections. He failed to produce antibodies in response to pneumococcal vaccine or typhoid vaccine. He produced no gamma globulin, although his other serum proteins were within normal range. Other cases have since been found, and there is some evidence that the condition may be congenital or acquired. No plasma cells were found in the tissues of any of the cases of this extraordinary disorder.

Plasma-Cell Tumors of the Mouse

Spontaneous plasma-cell tumors were recently found in some inbred strains of mice by Rask-Nielsen and Gormsen (11) in Copenhagen, Denmark and by Dunn (5) in Bethesda, Maryland. The tumors described by Dunn occur usually in the ileocaecal region of the intestinal wall. These tumors are transplantable in genetically similar host mice. More recently, Merwin in Bethesda found plasma-cell tumors in the peritoneal cavity of a mouse bearing a plastic chamber floating in the peritoneal fluid. Inside the fluid was sealed a bit of tissue of a mammary tumor that possessed the Bittner mammary tumor agent. The chamber was composed of plexiglass, millipore filter plastic, and acrylic cement. Still more recently, Merwin discovered that plasma-cell tumors developed in the presence of an empty millipore chamber. It is not as yet known whether suitable introduction of antigens could also induce the formation of plasma-cell tumors.

Moreover, transplantable plasma-cell tumors of mice are composed of plasma cells having the cytoplasmic juxtanuclear *'hof,'* but only a few of the cells show the cartwheel nucleus. By electrophoresis, Potter and Fahey (10) have shown that some of them produce excess gamma globulin, others excess beta globulin, and still others reveal different electrophoretic patterns. It is unknown whether in transplantation each tumor will continue to produce the same protein, or whether it may change to produce another type of abnormal protein. The factors controlling the production of such abnormal amounts of proteins are as yet unknown to the researchers.

Multiple Myeloma

Multiple myeloma is a lethal tumor of man that involves chiefly the bone marrow. Large masses of plasma cells appear in the marrow and elsewhere. It appears that these tumors arise in the bone marrow. This is the site at which they are first discovered and where they cause severe bone pain. However, the primary site of origin is still uncertain. In every case, the tumor is linked with an increase in the serum globulins. Some cases produce excess gamma globulin; others produce beta globulin. The cause is unknown.

Bence Jones Protein

In 1848, Henry Bence Jones (1), an English physician, described this peculiar "new substance" which occurred in the urine of a patient suffering "mollities ossium." The patient was a highly respectable tradesman in London with very fragile bones. This was the first description of a disease that has since been designated as multiple myeloma. The Bence Jones urinary substance is a protein which precipitates in acidified urine when heated to 55° C, returns to solution upon boiling, and reprecipitates on cooling the urine.

This protein is not normally present in the blood plasma except perhaps in traces; but it does appear in the urine of some cases of multiple myeloma. It has a small molecule (MW-35,000) that can easily escape through the healthy glometrular membrane of the kidney. This abnormal Bence Jones protein is produced in such great quantity that it often blocks the renal tubules. Bence Jones protein is present in the urine of about 40 per cent of the cases of multiple myeloma, and it has

HAROLD S. BLACK, LAMME MEDALIST

A MAN WINS A MEDAL...AND STRENGTHENS A PHILOSOPHY

The search for the "hitherto unattainable" sometimes ends in strange places.

For years Bell Laboratories engineer Harold S. Black pondered a problem: how to rid amplifiers of the distortion which unhappily accumulated as signal-transmission paths were made longer and amplifiers were added. There had been many approaches but all had failed to provide a practical answer.

Then one day in 1927 the answer came—not in a research laboratory, but as he traveled to work on the Lackawanna Ferry. On a newspaper, Mr. Black jotted down those first exciting calculations.

Years later, his *negative feedback principle* had revolutionized the art of signal amplification. It is a principal reason why telephone and TV networks can now blanket the country, the transoceanic cable is a reality, and military radar and missile-control systems are models of precision.

For this pioneer achievement, and for numerous other contributions to communications since then (some 60 U. S. patents are already credited to him), Mr. Black received the 1957 Lamme Medal from the American Institute of Electrical Engineers. He demonstrated that the seemingly "unattainable" often *can* be achieved, and thus strengthened a philosophy that is shared by all true researchers.

He is one of many Bell Telephone Laboratories scientists and engineers who have felt the challenge of telephony and have risen to it, ranging deeply into science and technology. Numerous medals and awards have thus been won. Two of these have been Nobel Prizes, a distinction without equal in any other industrial concern.

Much remains to be done. To create the communication systems of the future, we must probe deeper still for new knowledge of Nature's laws. We must continue to develop new techniques in switching, transmission and instrumentation for every kind of information-bearing signal. As never before, communications offer an inspiring challenge to creative men.

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been found in one of the several different plasma-cell tumors of mice. There is nothing peculiar, however, about the origin of this one plasma-cell tumor in mice to account for the production of the Bence Jones protein.

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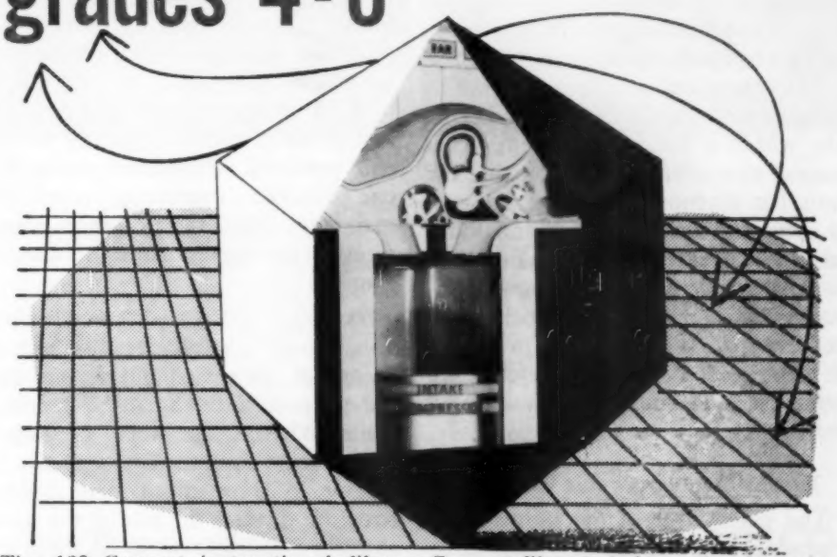

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Construction of Three-Dimensional Models and Techniques

By EUGENE J. VAN SCOTT

Dermatology Service, U. S. National Cancer Institute

Principles: Form and function of tissues are intimately interdependent and a study of one cannot be done with neglect of the other. Morphology is basic to the study of growth, since the latter is but the recognizable and measurable change in the former.

Morphological criteria may serve as indicators of physiologic events occurring within a biological system. Anatomical characteristics still provide the basis for diagnosis of many diseases. In certain diseases, however, anatomical characteristics provide more than diagnostic information and may indicate physiological or biochemical mechanisms. Although the principles of measurement in this exercise are elemental, they are nonetheless basic, and exploitable even today.

Tissues Involved in this Exercise

The outer layer of the skin and its appendages, i.e., epidermis, hair, nails, feathers, quills, and merocrine glands (mammary glands, apocrine glands of the axillae) are primarily used. Some of these structures (e.g., hair, feathers, quills) display rates of growth surpassed by no other tissue of the body, normal or neoplastic. All can display marked changes both in rate of growth and in biosynthesis of grossly measurable products. Characteristically some can become cancerous (epidermis, mammary glands); in others cancer rarely develops (hairs, apocrine glands).

Techniques: Reconstruction of three-dimensional models. The means for doing this are varied and depend upon the purpose for which the model is made. Whether the model is made to demonstrate minute details of the tissue or to show more gross over-all structure dictates the size of the model and the magnification to be used. The technique employed in this laboratory for reconstructing balsa wood models of hair follicles and other epidermal appendages, seventy-five times natural size, is as follows:

Through an inverted microscope inserted in the top of a large box (wood or heavy cardboard), every tenth histological section of skin (sections are of six μ thickness, cut parallel to skin surface) is projected onto drawing paper to produce an image enlarged seventy-five times. The image is transferred onto balsa wood slabs 3/16-inches thick. The balsa wood sections, cut from the slabs with a power jig saw (or coping saw), are glued together. Rough corners of the model are sanded and the model painted.

Other materials out of which models can be similarly made are cardboard, sheets of dental wax, or sheets of soft plastic.

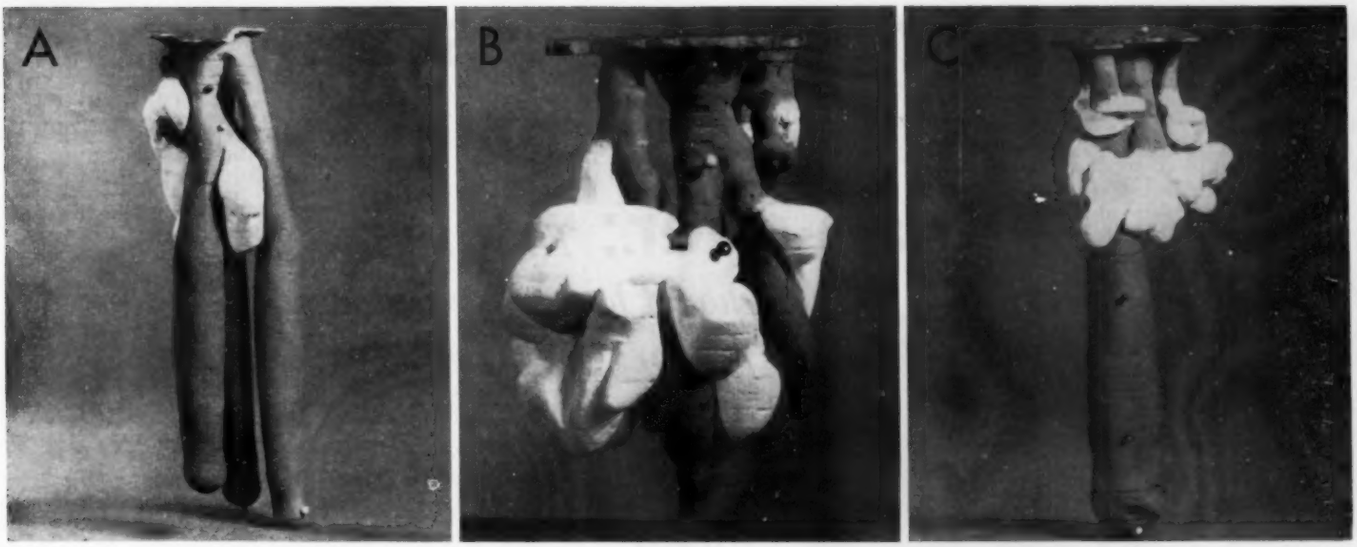
Participants are taken to the laboratory by Eugene J. Van Scott (Dermatology Service, NCI) for a demonstration of techniques for studying growth and morphology of the outer layer of the skin and its appendages.

Patterns and Rates of Growth of Hair, Nails, Skin Epithelium

Techniques that may be utilized to study growth of these tissues are applicable to laboratory animals as well as to humans. A few are as follows:

1. Microscopic examination of hair roots. Hair is manually pulled from the scalp or skin, and the root ends cut off and immersed in water in a small glass dish. Examination under a dissecting microscope reveals hairs that, from the appearance of their roots, can be identified as actively growing, resting, or showing evidence of disturbed growth in response to certain drugs, illness, and other factors.

2. Measurement of rates of growth of hairs, nails. Hairs are cut close to the skin surface. A capillary glass tube attached to a millimeter scale is placed over the hair and its length measured. Daily growth rates can be determined from measurements taken at intervals. The influence of drugs, physical agents, environment, etc., on growth rates may be studied.



Reconstructed models show (A) male beard hair follicle; (B) hair follicle from skin of back; and (C) scalp hair follicle.

Growth rates of nails (or claws) may be studied by simply measuring the change in distance between a mark scratched on the nail and some fixed proximal point on the digit concerned.

3. Observing growth of epidermis and other epithelial coverings. Growth of epithelial coverings can be stimulated by removal or partial removal of the epithelium. Removal by repeated "strippings" with cellulose tape is easily done. The "barrier" properties of skin to toxic substances can be ascertained by applying the substances to the skin before and after such stripping. The barrier property of human skin may be demonstrated by applying a substance such as vinegar to normal skin, from which no particular sensation is felt. Application to skin stripped with tape, however, gives the sense of pain because the surface barrier protecting nerve endings has been removed.

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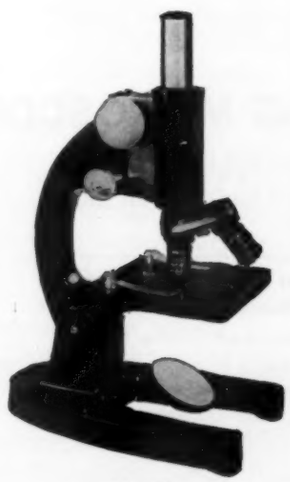

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Two-Dimensional Paper Chromatography

By THEODORE T. OTANI

Laboratory of Biochemistry, U. S. National Cancer Institute

THE technique of paper chromatography has simplified the separation and identification of many types of compounds, such as amino acids, sugars, organic acids, etc. The importance of this technique is emphasized by the fact that its chief developers, Archer J. P. Martin and Richard L. M. Synge, were awarded the 1952 Nobel Prize in Chemistry for this work.

The applications of paper chromatography in the biomedical field are numerous. To mention only a few, paper chromatographic techniques may be used (1) to identify enzymatic reaction products in mixtures without preliminary separation of products, (2) to study the progress of a reaction by noting the intensity of the spots given by the reaction products sampled at various intervals, (3) to study the concentration of compounds in tissues under normal and experimentally induced conditions, as for example, to study the amino acid concentration in normal and tumor tissues, and (4) to study the metabolic fate of test compounds administered to biological systems such as to microbiological or mammalian systems.

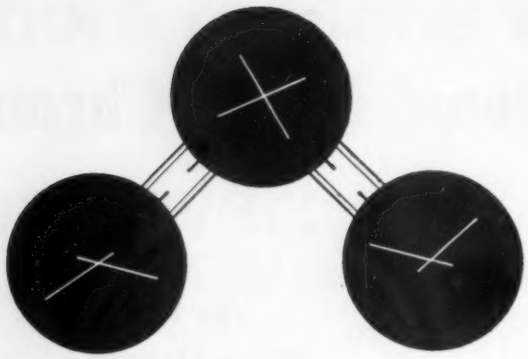
The demonstration described below is designed to point out the essentials of one useful form of paper chromatography, namely, the two-dimensional chromatography. For this an experiment to determine the amino acids in the urine of rats was chosen.

General Principles: Urines from rats kept on normal diets are desalted by means of a column containing a synthetic resin. Desalting is necessary to prevent interference in the subsequent development of color. The desalted urine is concentrated to a volume to contain about 10 to 20 micromoles of each amino acid per milliliter. A minute volume of this is spotted on paper and chromatographed.

Experimental Procedure: Urine is collected from rats in metabolism cages for three days. A suitable metabolism cage could be improvised as follows: Cut a circular piece of a fine-mesh wire gauze (about 10 to 20 mesh) approximately 10 cm in diameter and set it inside a short-stemmed chemical funnel (200-mm diameter). Stretch a coarse, large-mesh wire gauze (about ½-inch openings) and securely fit over the top of the funnel. Invert a round-type wire cage, or a 4-liter beaker on it. (An all-glass metabolism cage could be obtained from Glass Blowing Associates, 10515 Metropolitan Avenue, Kensington, Maryland.)

The three-day urine, about 80 ml, is diluted to 150 ml with water, and 20 ml of the diluted urine is pipetted onto a column filled with Dowex 50 resin in the hydrogen-ion form. (See C. G. Baker, "Chromatography and Paper Electrophoresis," *The Science Teacher,* 23:192, May 1956, for technique of preparing the adsorption column, but use glass wool in place of cotton.) Water is passed through the column. The effluent first turns acid, then neutral to litmus. The column is subsequently eluted with 2N ammonium hydroxide and that portion of the ammonia effluent which gives a positive test with ninhydrin is collected. For the ninhydrin test, one or two drops taken from the column tip are put on a piece of filter paper. The spot is dried and treated with a few drops of 0.25 per cent ninhydrin solution in acetone. The paper is dried by a stream of dry hot air (hot fan). A positive ninhydrin test usually gives a purple spot. This ammonia effluent fraction is concentrated until a spot test with ninhydrin gives a moderately strong positive test. By means of a 0.1-ml pipette, 0.003 ml of this solution is pipetted onto a Whatman No. 1 filter paper, 20 cm square, at the lower left-hand corner about 2.5 cm from the two edges. After the spot has dried,

Examination is made of an improvised method of paper chromatography suitable for use in high school science classes as Theodore T. Otani (Laboratory of Biochemistry, NCI) continues his lecture.



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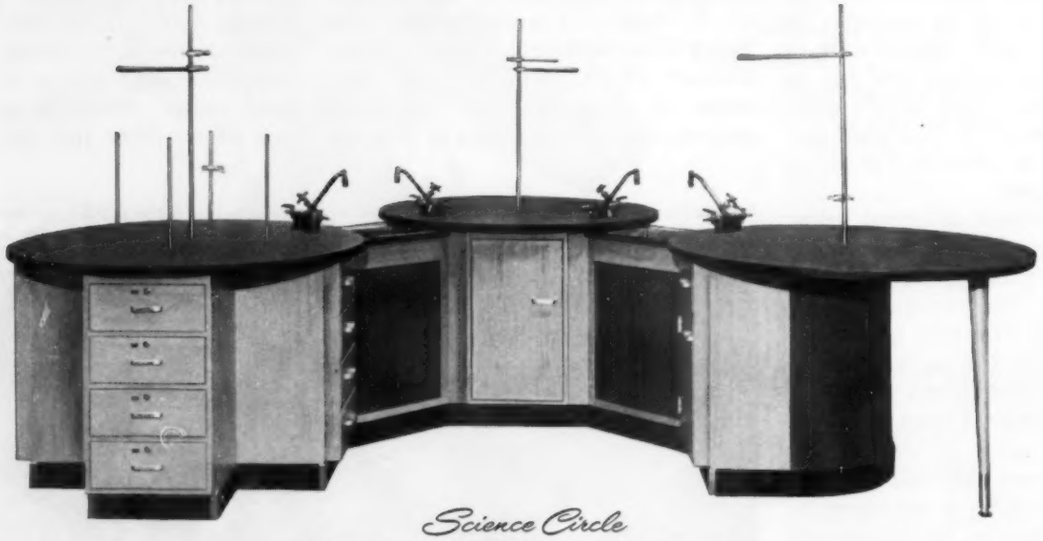

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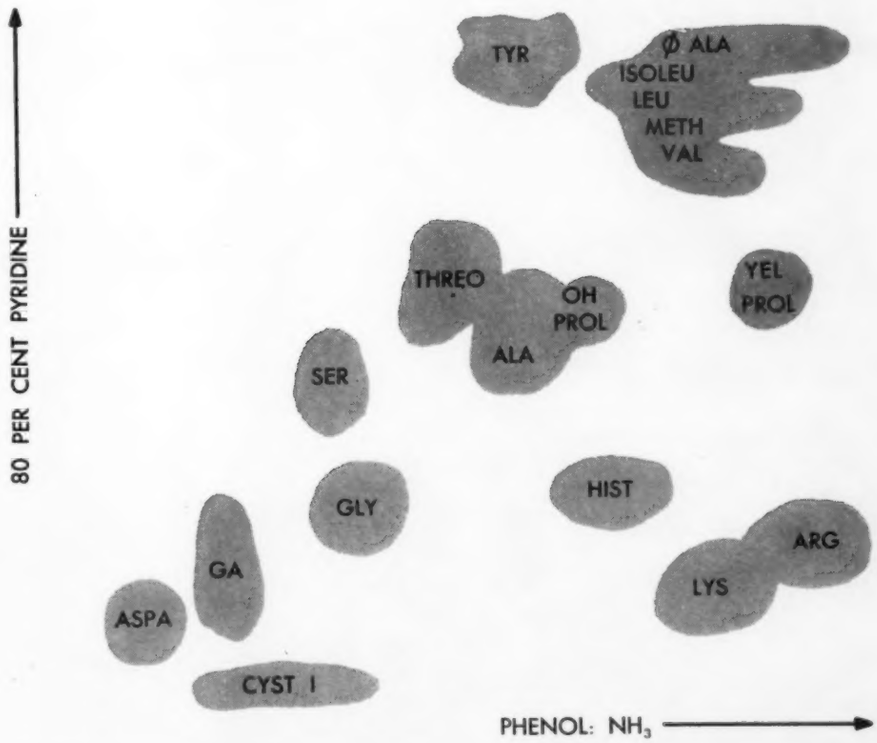
The appearance of a completed standard chromatogram is shown in Figure 1. Each spot on the experimental chromatogram can be identified by comparison with a standard compound spotted and chromatographed under identical conditions.

Materials: Most of the items are available from laboratory supply houses.

1. A 1- x 25-cm column with coarse sintered glass disc.
2. Dowex 50 resin, X8, 200 to 400 mesh. Dow Chemical Company, Midland, Michigan.
3. Whatman No. 1 filter paper sheets, 20 x 20 cm.
4. Pipettes, 0.1-ml capacity, graduated in 0.001-ml units.
5. Pyridine.
6. Phenol, liquefied. (Caution: Highly caustic; avoid contact with skin). Mallinckrodt Chemical Works, New York.
7. Glass jar or tank with glass lid, at least 12 inches high. A 4-liter beaker with parafilm lid will be a convenient substitute for single experiments.
8. Ninhydrin. Nutritional Biochemicals Corp., Cleveland, Ohio.
9. Acetone.
10. Surgical tray, approximately 3 x 2 x 18 inches.
11. Hot-air fan.

A TYPICAL CHROMATOGRAM



ALA . . . . . Alanine	LYS . . . . . Lysine
ARG . . . . . Arginine	METH . . . . . Methionine
ASPA . . . . . Aspartic Acid	OH PROL . . . . . Hydroxy Proline
CYST I . . . . . Cystine	Ø ALA . . . . . Phenylalanine
GA . . . . . Glutamic Acid	PROL . . . . . Proline
GLY . . . . . Glycine	SER . . . . . Serine
HIST . . . . . Histidine	THREO . . . . . Threonine
ISOLEU . . . . . Isoleucine	TYR . . . . . Tyrosine
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FIGURE 1.

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Teaching Mendel's Laws of Heredity

By MICHAEL POTTER

Laboratory of Biology, U. S. National Cancer Institute

THE last one hundred years have seen the beginning and the explosive growth of the science of genetics. This knowledge plays an important role in almost every phase of biological science and more and more is becoming a part of our domestic life. Modern genetics originated with Gregor Mendel and his experiments with peas. The principles of heredity that can be demonstrated from hybrid crosses are fundamental. A live demonstration establishes a strong working comprehension of the laws of heredity. In reality such a demonstration depends upon the availability of an established biological system.

The widespread use of inbred strains of mice in research laboratories throughout this country and the world, and their availability commercially provides such a system. This paper describes how to perform experiments with certain of the most widely used *inbred* strains of mice. The chief reason *inbred* strains of mice are essential is that the inbreeding process (consecutive brother-sister matings of twenty or more generations) has assured homozygosity for most genes, and in particular the genes controlling coat color.

The coat color of the mouse is controlled by many genes. Only four nonlinked, autosomally located genes, (A, a, B, b, C, c, D, d) are involved in determining the coat color of the mice listed in Table I. Excellent background reading for this subject is the first five chapters of the *Principles of Genetics*, Sinott, Dunn, and Dobzhansky, Fifth Edition, McGraw-Hill Book Company, Inc., New York. The coat color genetics of mice is frequently discussed.

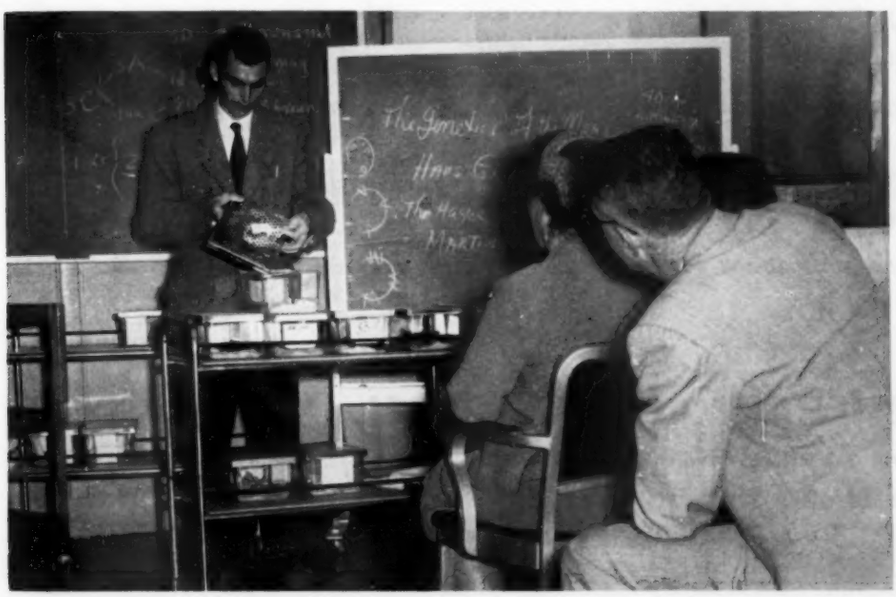
General Facts About Inbred Mice

Since inbred mice are usually maintained in laboratories where they are accustomed to constant temperature and air conditioning, importing them to the classroom may require some time for acclimatization before they will breed. Diurnal room temperature changes should not be great. A reasonable temperature for the room should be 70 to 78° F.

The cages may be glass jars or made of plastic (see photograph) with metal tops to insure that they are escape-proof. Crowding of mice is to be avoided. Five adult mice to one jar or eight to one of the plastic cages is the maximum. Mothers with litters will exceed this number in some cases. The bottoms of the cages should be covered with sawdust. The cages should be cleaned twice weekly, washed with hot soapy water, and then thoroughly rinsed with water and dried.

The gestation period of the mouse is eighteen to twenty-one days. Most females of many strains give birth on the nineteenth day. Mice can be weaned when twenty-eight to thirty-five days of age and will begin breeding shortly thereafter. Mice can be fed Purina Laboratory Chow.

Michael Potter (Laboratory of Biology, NCI) explains coat color genetics in mice. Many basic principles of genetics can be taught effectively to students at the high school level, using inbred strains of mice.



General Experimental Plan

Mice from two of the inbred strains listed in Table I should be selected, ordered, and established in the laboratory in the fall. Two males and four females of each strain should be obtained. Two females of Strain *1* should be mated with a male of Strain *2*, and the reciprocal mating should be simultaneously established. The remaining mice should be mated and maintained as inbred strains. Before the matings are made, isolate the males and females for three or more days, and then of course allow twenty-one days. Mice born before the expected time will have resulted from uncontrolled matings and cannot be counted. The progeny of the hybrid matings will be F_1 hybrids. Cages of these hybrids, one male with three females, should be established. Four cages of (F_1 x F_1) should be established to insure adequate numbers of F_2 mice.

Four principles should be stressed during the breeding of the F_1 and F_2 generations: unit characters, dominance, segregation, and independent assortment.

Coat Color Genetics

The common available strains, along with their coat color phenotype and genotype, are listed in Table I. All

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TABLE I

The Coat Color Genotype and Phenotype of Six Commonly Used Inbred Strains of Mice

Strain	*Coat Color Phenotype*	*Genotype Gene Linkage Group*			
		Color	*Agouti*	*Black Brown*	*Dilution*
		(C, c)	*(A, a)*	*(B, b)*	*(D, d)*
		I	*V*	*VIII*	*II*
DBA/2	dilute brown	CC	aa	bb	dd
BAlb/c	albino	cc	AA	bb	DD
C3H	black agouti	CC	AA	BB	DD
C57BL	black	CC	aa	BB	DD
C57Br	brown	CC	aa	bb	DD
A	albino	cc	aa	bb	DD

of the genes have a dominant (symbolized by capital letter) and recessive (small letter) form, and the heterozygotes always resemble the dominant. The four pairs of genes A, B, C, D (four-unit characters) interact so that a variety of coat color types will appear in the F_2 populations.

The *C* gene in its dominant form (genotypes *CC, Cc*) determines whether the coat and eyes will be pigmented at all. Mice of the genetic constitution *cc,* regardless of the other genes carried, will have no eye or coat color pigment and will be albino.

The agouti genes, *A* and *a,* influence the character of the coat color. When dominant *AA,* or *Aa,* the coat color will have a ticked pattern; the undercoat will be brown, black, or gray, and the terminal hair will have a yellowish cast. In the recessive, *aa,* the coat color will be smooth and homogeneous. Most wild cottontail rabbits are brown agoutis.

The black-brown gene series determines whether the coat color will be black or brown. Mice with the genetic constitution *BB* and *Bb* will be black; *bb* mice, brown. Black-brown interacts with agouti *A* so that there are black agouti, and brown agouti, and also with nonagouti *aa* giving homogeneous black or brown mice.

The dilution gene, in the recessive form *dd,* dilutes the coat color; *e.g., aaBBdd* is slate gray, and *aabbdd* is a tannish gray (dilute brown).

The following coat color phenotypes are involved from the interaction of the four genes C, A, B, D:

cc plus any other	albino
Caabbdd	dilute brown
CAbbdd	dilute brown agouti
CaaBdd	gray
CABdd	dilute black agouti
CaabbD	brown
CaaBD	black
CAbbD	brown agouti
CABD	black agouti

The three factor crosses are suggested. A sample experiment of DBA/2 crossed with BAlb/c is described below.

TABLE II

	Mating			*Number of Factors Involved*	*F_1 Hybrid Phenotype*	*F_2 Phenotypes*
1.	DBA/2	x	BAlb/c	3	brown agouti	5
2.			C3H	3	black agouti	8
3.			C57BL	2	black	4
4.			C57Br	1	brown	2
5.			A	2	brown	3
6.	BAlb/c	x	C3H	2	black agouti	3
7.			C57BL	3	black agouti	5
8.			C57Br	2	brown agouti	3
9.			A	2*	albino	1
10.	C3H	x	C57BL	1	black agouti	2
11.			C57Br	2	black agouti	4
12.			A	3	black agouti	5
13.	C57BL	x	C57Br	1	black	2
14.			A	2	black	3
15.	C57Br	x	A	1	brown	2

*Obviously this cross will be useless for these purposes.

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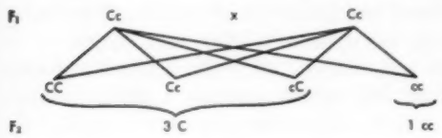
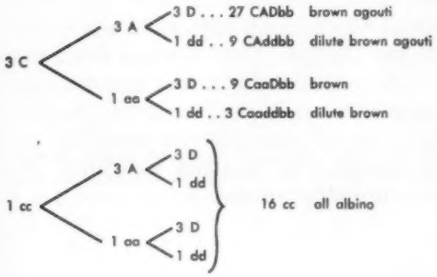
The DBA/2 mouse carries three recessive genes while BAlb/c, though albino, introduces two dominant genes A and D. The F_1 hybrids differ from either parent and will be uniformly brown agouti. Their genotypes are *CcAaDdbb*. The F_2 (F_1 x F_1) can be developed schematically as follows, beginning with the *C* gene. (The concept of meiosis and reduction of chromosomes can be brought in here.)



The simplified notation *C*, shown in the diagram, means *CC*, *Cc*, or *cC*.

Of the four possible genotype combinations there will be three dominant to one recessive; a 3:1 ratio.

It is then a simple step to repeat the process for each of the other genes involved. Finally both strains carry *bb*, and this should be added to the final genotype as follows:



The simplified notation D means *DD*, *Dd*, or *dD;* A stands for *AA*, *Aa*, or *aA;* etc.

It may be seen that there are sixty-four combination possibilities (27 + 9 + 9 + 3 + 16). The per cent of brown agoutis is 27/64 or 42.1. How does this figure compare with the number of brown agoutis you have raised? Also, the parental types have reappeared in the F_2, though they were lost in the F_1. (Segregation—The unit characters were not lost; they have now segregated out again, and in the proper recombinations express themselves as in the parents.)

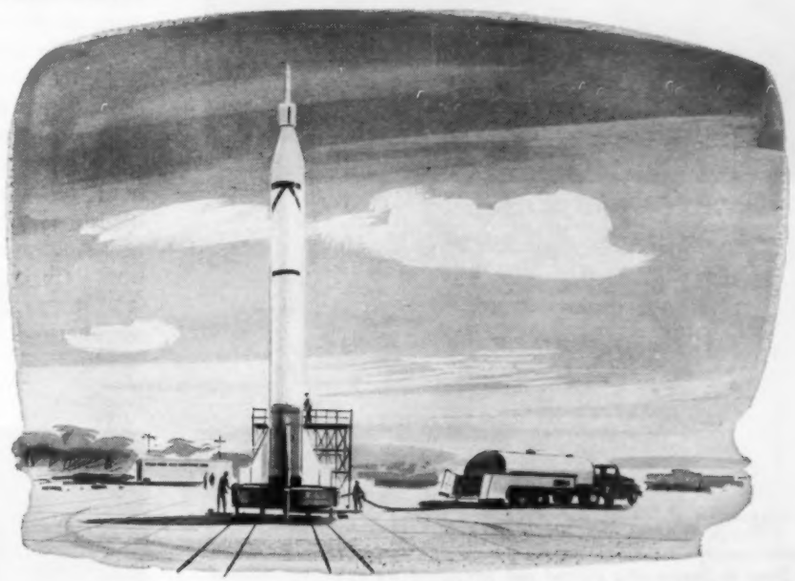
If the parent DBA/2 has been kept, individual students can be assigned albino mice of the F_2 generation to breed with a DBA/2 mouse. The DBA/2 male can be mated with several females, and when they are found to be pregnant, they should be isolated. In order to obtain a large enough population it might be necessary to remate them. The progeny of these crosses will of course vary with the genetic constitution of the albino, but the point can be made from the data obtained that the F_2 albinos did not all behave like the BAlb/c when mated to DBA/2. Hence, just because they are albino, they are not necessarily *ccAAbbDD* like BAlb/c, but in fact, they have their own independent genetic constitution.

Each gene, then, is independently inherited without influence of the others, unless there is linkage on the chromosome. (Independent assortment.) The subject of linkage is not treated here, but can demonstrated by using linked genes.

Materials

1. The inbred strains of mice mentioned in this paper can be obtained from the Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine.
2. A plastic cage can be purchased at a reasonable price from Maryland Plastics Company, Federalsburg, Maryland.

How are satellites launched?



(P. 328, Science Problems, 6th grade text)

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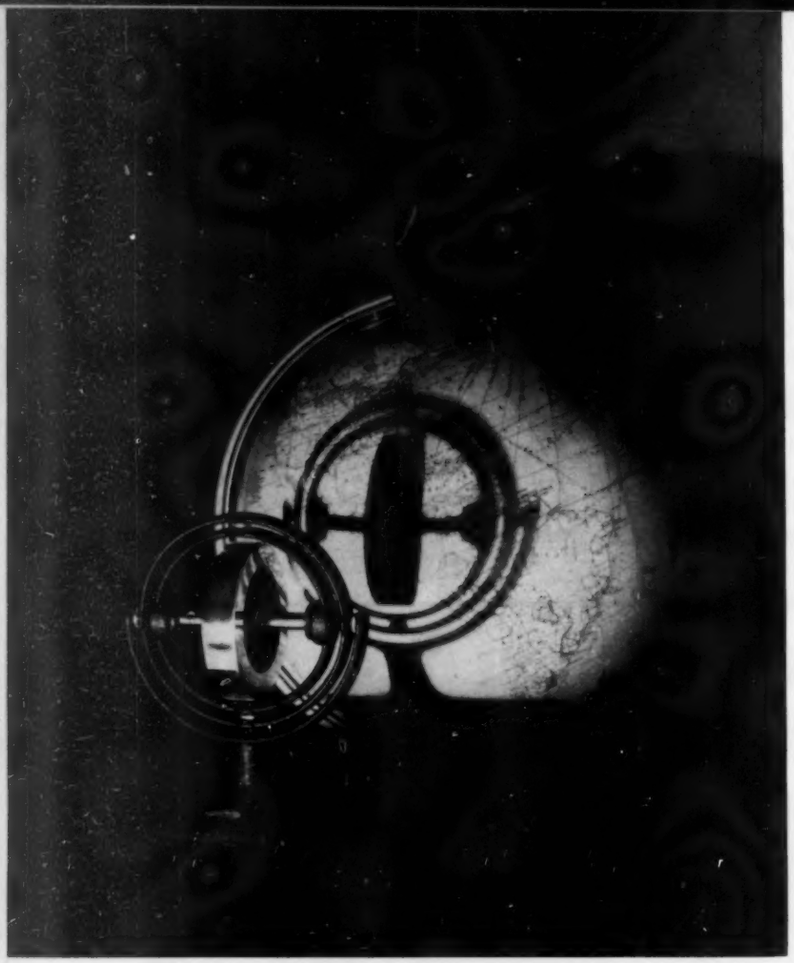

Tribute to a

GYROSCOPE, gyro-compass, stabilizer, gyro-pilot, gyro-top or spinning top—what significance are these in today's world of navigation by sea or air, of planes, missiles, and satellites, or of tomorrow's space ships?

The whole story was illuminated in the nation's capital when the Smithsonian Institution opened a three-month exhibit to mark the centennial anniversary (1860-1960) of the birth of an inventor, scientist, and industrial genius, Dr. Elmer A. Sperry. The exhibit, sponsored by the Sperry Board of Award with members from four engineering societies, was prepared by the Sperry Gyroscope Company to display Dr. Sperry's many historical inventions and their importance to modern-day technology. The first gyro-compass (the Delaware Compass), now a permanent part of the Smithsonian collections, along with his first patent for an electric dynamo, electric mining machinery, a trolley car, electric automobile, high intensity arc and searchlight, airplane instruments, automatic pilots, and rail flaw detectors—all were included.

Important as these were, along with his early notebook records, letters, photographs, and features from his life story, the *live* exhibit which included the introduction of his children and grandchildren brought another realization. Here was a figure in our own lifetime spanning the gap from individual inventor to modern industrial researcher—a model for future scientists.

The strange antics of the toy gyroscope have baffled children for generations. Although spinning tops were well-known in ancient China, and nineteenth century scientists considered the gyro an interesting phenomenon, it was Elmer A. Sperry who utilized and envisioned the unlimited potential of the gyroscope.

Playtoy of children and mathematicians—today's gyroscopes have taken their place in a new era of precision navigation and control.

a Scientist . . .

Dr. Elmer A. Sperry

In middle life he became fascinated by the action of the gyroscope or "spinning top." Delving deeply into the work of the French scientist, Leon Foucault, on his demonstration of the earth's rotation by a rotating wheel, he predicted that gyros, ". . . not only will guide our ships, but will have other important and far-reaching bearing on their operations. . . ."

Then he went to work to prove it and with his gyro-compass and Metal Mike he revolutionized navigation. And thus "gyros" moved from the toy counter into every facet of precision navigation—ships, airplanes, missiles, satellites, and tomorrow . . .?

It is the story of a small town inventor who by untiring energy and curiosity became director of his own research laboratory that opened up many new engineering fields such as automation, servomechanisms, and gyroscopics. His work also has far-reaching effect on the applications of flaw detection in rails and laboratory investigations of metals, ceramics, plastics, etc. In this era of mechanical, electrical, and electronic devices and equipment, his contributions will be more fully realized by each advance in these areas of research and technology.

Editor's Note: Information on the history or current use of gyroscopes may be obtained by writing the College Relations Department (R. 206), Sperry Gyroscope Company, Great Neck, New York.

Viewer examines Sperry's first gyro-compass (now permanently housed in the Smithsonian Institution) which was developed in 1911 to replace the magnetic compass so often inaccurate for sea navigation. The compass was successfully tested on the U. S. S. *Delaware* and contributed to the success of many naval battles during World War I. From this device, the first aerial gyro unit was conceived and its development has contributed to robot aircraft and guided missile applications, as well as a navigation system for nuclear submarines.

To the teachers and students of our generation, here is an inspiring example of the pioneering and investigative spirit characteristic of our nation.

Dr. Elmer A. Sperry, with whom I worked for twenty years, was born October 12, 1860 in the town of Cortland, New York. It was the science teacher at the Normal School who opened the mind of this inquisitive boy as to how electricity might be put to work in many new fields. His enthusiasm for trying out new things grew so rapidly, that like many others of his generation, he could not wait to finish his formal education before inventing things of his own. At the age of 19, he built an electric arc lamp; at 20 he had formed his own company; at 24 he invented the first electric coal mining machinery, and from that came the coal cutting machine and an electric mine locomotive. And so the story goes on . . .

From the curiosity, effort, and work in his early life to learn, investigate, perceive, and inspect were begun the industrial companies he founded through his outstanding services, inventions, and achievements in safety, comfort, and technological progress for today and the future.

Preston R. Bassett
Past-President, Sperry Gyroscope Company
Chairman of the Board, Polytechnic Institute of Brooklyn, New York

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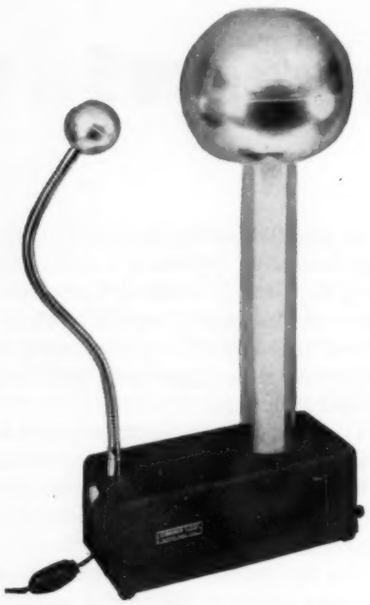

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Operates on 110-volt A.C. or 110-volt D.C. Includes: Discharge Terminal, Lucite Insulating Cylinder, Latex Charge-Carrying Belt, Discharge Ball with Flexible Shaft, Accessory and Ground Jacks, Cast Metal Base with built-in Motor Drive, Connecting Cord, Plug, Switch, and Operating Instructions.

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NO FRAGILE PARTS—Durability was a prime consideration in the design of the GENATRON which with the exception of insulating members, is constructed entirely of metal.

The only part subject to deterioration is the charge-carrying belt, which is readily replaceable.

NO TRANSFER BODIES—In all conventional influence machines, whether of Holtz or Wimshurst type, electrical charges are collected and conveyed (from rotating plates to electrodes) by a system of "transfer bodies." Such bodies have always taken the form of metal brushes, rods, button disks or segments—each of which inevitably permits leakage of the very charge it is intended to carry, and thereby sharply limits the maximum output voltage.

It is a distinguishing difference of the GENATRON that electrical charges, conveyed by a non-metallic material, are established *directly upon the discharge terminal.* The attainable voltage accordingly depends only upon the geometry of that terminal and the dielectric strength of the medium by which it is surrounded.

Unique Features of the CamboscO Genatron

DISCHARGE TERMINAL Charges accumulate on, and discharge takes place from, the outer surface of a polished metal "sphere"—or, more accurately, an oblate spheroid.

The upper hemisphere is flattened at the pole to afford a horizontal support for such static accessories as must be insulated from ground. A built-in jack, at the center of that horizontal area, accepts a standard banana plug. Connections may thus be made to accessories located at a distance from the GENATRON.

CHARGE-CARRYING BELT To the terminal, charges are conveyed by an endless band of pure, live latex—a CamboscO development which has none of the shortcomings inherent in a belt with an overlap joint.

DISCHARGE BALL High voltage demonstrations often require a "spark gap" whose width can be varied without immobilizing either of the operator's hands.

That problem is ingeniously solved in the GENATRON, by mounting the discharge ball on a flexible shaft, which maintains any shape into which it is bent. Thus the discharge ball may be positioned at any desired distance (over a sixteen-inch range) from the discharge terminal.

BASE...AND DRIVING MECHANISM Stability is assured by the massive, cast metal base—where deep sockets are provided for the flexible shaft which carries the discharge ball, and for the lucite cylinder which supports, and insulates, the discharge terminal.

The flat, top surface of the base (electrically speaking), represents the ground plane. Actual connection to ground is made through a conveniently located Jack-in-Head Binding Post. The base of the Genatron encloses, and electrically shields, the entire driving mechanism.

PRINCIPAL DIMENSIONS The overall height of the GENATRON is 31 in. Diameters of Discharge Ball and Terminal are respectively, 3 in. and 10 in. The base measures 5¼ x 7 x 14 in.

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Classroom IDEAS

Chemistry

Demonstrations of Heredity

By HAROLD J. WILSON and DOUGLAS A. ROBERTS
Avon-Grove Area Joint Schools, West Grove, Pennsylvania

By using chemicals it is possible through teacher demonstration, or student experimentation, to show Mendel's Laws of Heredity. If the demonstrations are done by the teacher, the use of test tubes will help the student to see the reactions better. If the student is to do the experiment, spot plates should be used.

I. Demonstration of the cross between pure parents showing Mendel's Law of Dominance.

Chemicals
1. Y—Potassium Chromate—(K_2CrO_4)
2. y—Potassium Sulfate—(K_2SO_4)

		Y	Y
	y	Yy	Yy
One parent (colorless)	y	Yy	Yy

One parent (pure yellow)

First generation—100 per cent hybrid yellow

II. Demonstration of the cross between hybrid parents showing Mendel's Law of Segregation.

Chemicals
1. Y—Potassium Chromate—(K_2CrO_4)
2. y—Potassium Sulfate—(K_2SO_4)

		Y	y
One hybrid parent	Y	YY	Yy
	y	Yy	yy

One hybrid parent

Second generation—3:1
A third generation will be necessary to prove that the make-up of the second generation was as follows: 25 per cent pure yellow 50 per cent hybrid yellow 25 per cent colorless

III. Demonstration of the cross of four characteristics between hybrid parents showing Mendel's Law of Unit Characters.

Chemicals
1. Y—Potassium Chromate—(K_2CrO_4)
2. y —Potassium Sulfate—(K_2SO_4)
3. X—Barium Nitrate—($Ba(NO_3)_2$)
4. x —Water—(H_2O)

		YX	Yx	yX	yx
One hybrid parent	YX	YYXX	YYXx	YyXX	YyXx
	Yx	YYXx	YYxx	YyXx	Yyxx
	yX	YyXX	YyXx	yyXX	yyXx
	yx	YyXx	Yyxx	yyXx	yyxx

One hybrid parent

Third generation
- YX—Yellow precipitate 9
- Yx —Yellow liquid 3
- yX —White precipitate 3
- yx —Colorless liquid 1

Physics

Seeing Sound

By JAMES WILLIAMS, Silver Street School,
New Albany, Indiana

Major concept: Sound is vibration

Take an old radio or record player from its case. One with a large speaker will give the best results. Glue a tiny piece of mirror to the cone of the speaker near the center. The cone vibrates most near the center.

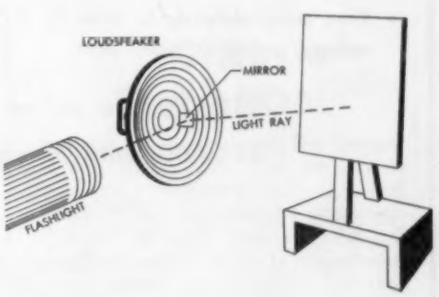
Set up a movie screen or make a small screen from white paper. Arrange the flashlight and the screen so that the beam of light is reflected onto the screen.

Darken the room and turn on the radio or record player. The moving reflection will show that the cone vibrates.

Students may also feel the vibrations by putting their fingertips on the cone near the center. They should observe that loud sounds are made by stronger vibrations, and that sounds of low pitch cause slower vibrations than sounds of higher pitch.

If a public address system is available, the experiment can be controlled better. Students can see, hear, and feel the different patterns of sound they make when they speak loudly or softly, or with higher or lower pitch. The tiny bit of mirror glued to the cone will not hurt the speaker or change its sound in any noticeable way.

SEEING SOUND



Extreme care should be taken not to puncture or tear the paper cone of the speaker. When the radio or record player are out of their cases, do not touch if plugged into the wall.

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BOOK Reviews

Democratic Educational Theory. Ernest E. Bayles. 266p. $4.75. Harper and Brothers, 49 East 33rd St., New York 16, N. Y. 1960.

This is an authentic presentation of an educational philosophy which has doubtless given more insight into the educative process than any other in the last generation. Confessedly in the Dewey tradition, it is one of the few references that combines an intimate understanding of the philosophy in question with readability for advanced undergraduates in education. Moreover, it is seasoned with a mature wisdom which derives from a rich experience in the profession. Hence the work authenticates the first sentence of the preface. "This book represents an accumulation of more than thirty years of my thought on what ought to be the major tenets of a genuinely democratic educational program, one which is comprehensive and consistent and at the same time practical."

There is a unique appropriateness for a review of this book in a publication for teachers of science, for it holds that the only finally reliable test for truth lies in a generalization of the scientific method for the whole of life. It proposes the scientific outlook as the most desirable thought pattern from which to approach the full range of mankind's problems for a harmonious, free, and democratic society. "Thus a thought pattern (or outlook) which is scientifically satisfactory is one which satisfies the criterion of *adequacy and harmony of outlook or conclusion in light of obtainable data.*" This outlook "covers, harmoniously, a very wide expanse of American ideals and aims. Especially is it thoroughly in keeping with democratic educational requirements, for it provides the teachers with an adequate instrument for *guiding* pupil thinking yet at the same time avoids indoctrination." (See p. 208.)

Working on this assumption with respect to validating knowledge, the author combines a way of learning with cooperative endeavor and arrives at a democratic way of life. "In working together, on the basis of democratic governance and of employing the scientific way to attain truth (which is indeed a democratic way), men can and do achieve far more than any or all of them can or could possibly achieve by working each to himself alone." (See p. 138.)

Chapters of the book appropriately cover such topics as: Experiments with Reflective Teaching, Is Modern Science Inductive, and Relativistic Value-Theory. These are balanced with chapters of a practical-professional character, and applications to practice and to life are abundant throughout. The large view is generously provided in such chapters as: Idealism, Realism, and Pragmatism; Religion and Character Education; The Meaning of Appreciation; and The Present Status of Educational Theory in the United States. The whole is consequently comprehensive, balanced, and clearly a carrying forward of an honored and distinguished perspective in educational theory.

EVERETT J. KIRCHER
The Ohio State University
Columbus, Ohio

Physics Is Fun. G. Niese. 150p. $2.95. Astro-Computing Books, Box 5540, Washington 16, D. C. 1960.

The author has performed an excellent job of describing and explaining the various phenomena of physics that we encounter every day. The experiments are simple and easy to perform, yet in performing them the reader will learn the basic laws of physics.

The experiments in this book are drawn from four branches of physics: mechanics, heat, sound, and optics. The section on mechanics illustrates the principal laws governing the movement of solids, liquids, and gases, and explains the concept of force.

Under the section on heat are described the properties of steam, fog, and ice, and the work of a red-hot stove burner. The physicist is also interested in learning about the origin of sound, and the laws that govern all the sounds that are heard every moment. How do sounds come into being? How can a sound be recorded on a phonograph record? What causes an echo? The reader will find the answers to these questions by performing several simple experiments.

About half of the experiments in this book have been taken from the field of optics. In this section are found experiments using mirrors, experiments illustrating reflection and refraction, use of the magnifying glass and the camera, the function of the human eye, and several interesting demonstrations in color.

In this book the reader will discover something new, interesting, and worthwhile.

ROBERT NELSON
Junior High School
State College, Pennsylvania

Teaching Science Through Conservation. Martha E. Munzer and Paul F. Brandwein. 470p. $7.50. McGraw-Hill Book Company, Inc., 330 West 42nd St., New York 36, N. Y. 1960.

This book satisfies a long-felt need for a publication which brings together conservation ideas and concepts and demonstrates how they may be presented in science classes. Science teachers are aware of the many activities in the biological sciences which can be treated appropriately in relation to the conservation unit. This volume can help to accomplish integration of conservation activities into existing courses such as general science, chemistry, and physics, as well as biology. The activities described are appropriate for both laboratory and field study, and for teacher demonstrations or pupil experiments.

The authors categorize resources into four groups: Renewable, Nonrenewable, Inexhaustible, and New and To-be-developed Resources. An annotated bibliography includes lists of teaching aids—films and filmstrips, selected books, pamphlets, and magazines. An index offers a topical outline of a conservation course as a teacher's guide.

The book is highly recommended for science teachers as an addition to their professional library. This reviewer was impressed with the excellence of the volume, which he has learned to expect from work presented by these authors.

H. SEYMOUR FOWLER
Pennsylvania State University
University Park, Pennsylvania

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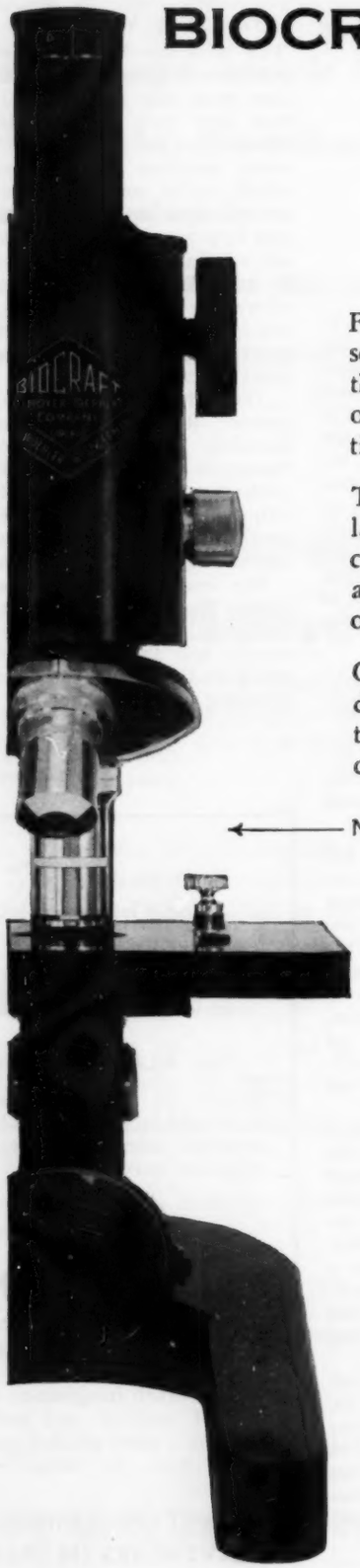

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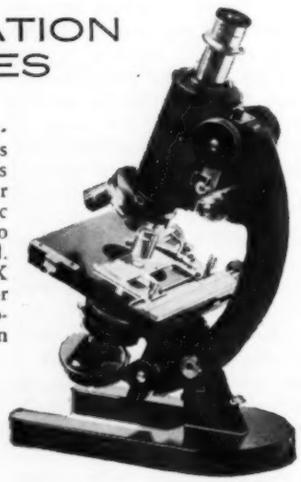

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NSTA Activities

Regional Meeting, Tempe, Ariz.

The theme of a regional conference to be held in Tempe, Arizona, November 4-5 will be "The Science Teacher." Attention will be focused on his needs, problems, responsibilities, and opportunities through panel discussions and talks by teachers. Speeches by prominent leaders in industry, science, and education will be presented in the Friday luncheon meeting and the Saturday morning session. Lecture-demonstrations and student exhibits will complete the program. Meetings will be held in conjunction with the Arizona Science Teachers Association during the annual convention of the Arizona Education Association at Arizona State University, Tempe.

Teachers wishing to make plans at this time may write to the Chamber of Commerce or directly to local hotels and motels for reservations. Since facilities will be crowded at this late fall season, early arrangements are encouraged.

Chapters and Associated Groups

One of the important decisions reached by the NSTA Board of Directors in its Los Angeles meeting last June was approval of general plans and recommendations for establishing state chapters of NSTA. It was decided also to retain the opportunity for other science teacher organizations, including those in foreign countries, to affiliate as associated groups.

The question had been under study for more than a year. Representatives of approximately 20 state science teacher organizations, all of them now affiliated with NSTA, shared in developing the recommendations. Policies and practices of other NEA departments were studied carefully for ideas and procedures that might be adapted to science groups. A committee to refine the operational policies for enrollment of state chapters and associated groups of NSTA has been appointed with members as follows: Alan H. Humphreys, *Chairman,* University of Texas, Austin—representing the Texas Association of Science Teachers; Josephine F. Bordonaro, Onondaga Valley Academy, Syracuse, New York—representing the New York State Science Teachers Association; Hugh Allen, Montclair State College, Upper Montclair, New Jersey—representing the New Jersey Science Teachers Association; Carl P. Swinnerton, Pomfret School, Pomfret, Connecticut—representing the New England Association of Chemistry Teachers; and Lawrence M. Watts, Jefferson County Public Schools, Lakewood, Colorado—representing the Colorado Science Teachers Association.

In addition to authorizing state chapters, the Board approved the formation of a National Advisory Council on Science Education. This council will be composed of delegates from the state chapters, associated groups, and sections of NSTA, in addition to the standing committee chairmen and the Board of Directors. The new council will hold annual meetings prior to the annual business meeting of the NSTA Board of Directors and make recommendations.

Motion Picture Research Project

Your Association has recently been offered a rare opportunity to undertake a project in communications research. Under a grant from the National Cancer Institute and with the advice of an appropriate committee of science teachers and scientists, research will be done to seek improved ways to portray, by way of film, the activities and modes of inquiry employed by research scientists. A series of motivational films, for use at the junior high school level, will be based on the results of this research. The underlying hypothesis is that improved methods of communication between practicing scientists and youth, who sooner or later will utilize or be affected by developments in the field of science, will go a long way toward motivating and encouraging an ample number of young people to follow careers in science and related fields.

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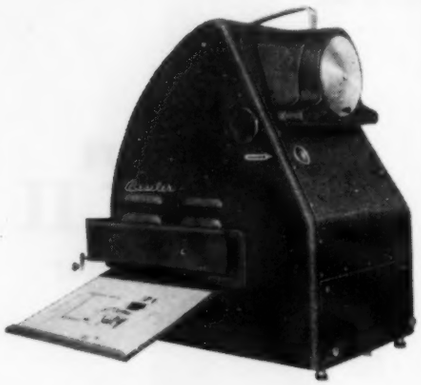

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A research scientist and an educational psychologist will spend one year in doing the communications research and supervising the production of the films. The principal actor in each of the films will be a scientist. As soon as a method of distributing these films has been determined, it will be announced in this column.

Second Science Facilities Study

The increasing tempo on all fronts of school science requires NSTA's critical attention to the various factors that bear on the effectiveness of science teaching. Changing emphases, new courses, and expanded enrollments cause us to re-examine our resources. Now we begin a second study of science facilities.

Such curricular developments as those coming from the Physical Science Study Committee, the Chemical Bond Approach Committee, and the Biological Sciences Curriculum Study lead to the conclusion that science facilities are limiting factors in our professional efforts. The two conferences planned by NSTA and sponsored by the National Science Foundation—science in the elementary school, and science in the secondary school—support the same conclusion. Projections of school population and of the supply and preparation of science teachers add weight to the need for a further study of science facilities. Provisions under the National Defense Education Act accentuate the need and urgency for careful investigation.

Under a grant from the Laboratory Equipment Section of the Scientific Apparatus Makers Association, a Seminar on Science Facilities was held in New York City on March 2 and 3, 1960. The deliberations were directed toward the need, direction, and potential of a comprehensive study of facilities for school science. The following persons participated in the seminar: Matthew Brennan, Forest Service, U. S. Department of Agriculture, Washington, D. C.; John S. Cartwright, Superintendent of Schools, Allentown, Pennsylvania; Ralph E. Keirstead, State Department of Education, Hartford, Connecticut; E. S. Obourn, U. S. Office of Education, Washington, D. C.; Elra M. Palmer, Supervisor of Science, Baltimore, Maryland; James A. Rutledge, University of Nebraska, Lincoln; Murl B. Sailsbury, Evanston Township High School, Evanston, Illinois; Stanley E. Williamson, Oregon State College, Corvallis; and John S. Richardson, The Ohio State University, Columbus, *Chairman.* The following observers participated in the seminar discussions: Robert H. Carleton, Executive Secretary of NSTA; James R. Irving, Executive Secretary, Laboratory Equipment Section of SAMA; and S. S. Coston, Vice-President, John E. Sjostrom Company.

The principal result of the seminar was to launch a two-phase program. The first phase of the program will involve a thorough investigation of such factors as the background of science facilities, the directions of curriculum development, projections of school population, the national need for scientists and engineers, and the probable quantity and quality of science teachers. Fred Schlessinger of the Ohio State University has been named as the principal investigator for the study. With the assistance of a Steering Committee, he will administer the project and prepare a relatively brief report. The substance of the report will include the identification of policies and guidelines for the future development of science facilities in schools. The report will be directed to school administrators, science teachers, members of boards of education and state departments of education, specialists in school plant planning, and equipment suppliers. It is anticipated that Phase Two will include the production and distribution of audio-visual materials pertinent to the development of science facilities, the scheduling of regional conferences, and further study and report publication.

The Steering Committee includes the following members: Louis Alcorta, Galileo High School, San Francisco, California; Matthew Brennan, U. S. Department of Agriculture, Washington, D. C.; John S. Cartwright, Superintendent of Schools, Allentown, Pennsylvania; Elra M. Palmer, Supervisor of Science, Baltimore, Maryland; Howard M. Phillips, President, Alabama State College, Montevallo; and John S. Richardson, The Ohio State University, Columbus and Stanley E. Williamson, Oregon State College, Corvallis, *Co-chairmen.* An Advisory Committee will be named at a later time. Its members will represent the principal related groups from the scientific and professional societies, government agencies, and the equipment industry, as well as science teachers and research scientists.

Convention Report, 1961

The General Planning Committee reports constant progress in their plans and preparations for the Ninth Annual Convention of NSTA to be held in March at the Hotel Sherman in Chicago, Illinois.

Some 300 supervisors, coordinators, and directors of science in state departments and local school systems will open the convention on Friday, March 24. The program is being planned under the direction of the chairman of NSTA's Section for Supervisors, Samuel Schenberg of New York City. Wind-up sessions will be held on Wednesday, March 29 by another Section of NSTA, the Association for the

Education of Teachers in Science. In charge of planning is Harold E. Tannenbaum, President of AETS who is located at State University Teachers College, New Paltz, New York.

Between the meetings of these two groups are four days jam-packed with a great variety of offerings for all NSTA members and friends who can attend. A complete program schedule will be listed in the November issue of *TST*. Refer later to the December issue for items that will include not only more detailed information but also the necessary forms to make advance registration and hotel reservations. It is extremely important that everyone who can possibly do so register in advance. The Hotel Sherman will accept reservations for our convention beginning December 1. You can save money and help ease the housing problem by arranging to share a room or suite with one, two, or three others.

If you would like to take an active role in the convention, there are areas in which additional volunteers might contribute. Offer your services to one of the members of the General Planning Committee named below, specifying exactly the nature of your contribution. Give as much detail as possible when you write.

Currently, two sets of Parallel Sessions featuring panels and group presentations are being planned:

Topics of General Interest

- Youth Activities in Science Outside the School.
- Successful Gifted Student Programs.
- Mobile Science Laboratories.
- Helpful Services Available to Science Teachers.
- Teacher Projects to Aid Professional Growth.
- Teaching and Evaluation.
- National Curriculum Trends.
- Team Teaching in High School Science.

If you feel you can contribute to one of these topics, get in touch with Frank L. Balmer, York Mills Collegiate Institute, 490 York Mills Road, Willowdale, Ontario, Canada.

Topics Specifically Related to the Professional Problems of Science Teachers

- Keeping up with the times in subject matter.
- Achieving optimum physical conditions for effective science teaching.
- Developing adequate science programs and curricula for today's children and youth.
- Seeking to advance the Profession, and to advance in the Profession—to develop latent leadership among classroom science teachers.

To assist with any of these or similar topics write to John B. Chase, Jr., University of North Carolina, Chapel Hill, North Carolina.

The entire 1961 convention has been built on the conviction and faith that the classroom science teacher can assume a strong leadership role in the emerging school science programs. The program design will open up many opportunities for *you* and 2500 other science teachers to demonstrate that this faith is well founded.

Budget for 1960-1961

As the profession of science education continues to grow, the program of your Association must also grow. In this and the May issue of *TST*, the new projects which the NSTA is planning have been described. An expanding program calls for an expanding budget. This year's budget estimates in summary form are listed below.

Cash Income	
Membership and Subscriptions	$146,000
Convention and Meetings	47,500
Advertising	131,000
Sales—Publications and Materials	50,000
Contributions	62,000
Grants and Special Projects	73,500
Total	$510,000
Balance from 1959-60	50,000
GRAND TOTAL	$560,000
Cash Expenditures	
I. Science Education Activities for Youth	
A. Future Scientists of America	$ 15,000
B. FSA Awards and Youth Science Congresses	21,000
C. "Vistas of Science" Book Series	10,000
D. Special Projects	5,000
I. Sub-total	$ 51,000
II. Professional Activities for Teachers	
A. Periodicals and Other Publications	$ 96,000
B. Packet Service and Registry	65,000
C. Convention and Other Meetings	35,000
D. Special Projects	59,600
II. Sub-total	$256,645
III. NSTA Activities for Members	
A. Staff, Board, Operation	$215,255
B. Committees, Chapters, and Sections	21,500
C. Contingency and Reserve Development	15,600
III. Sub-total	$252,355
GRAND TOTAL	$560,000

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By E. C. Champion and N. Davy—An enlarged edition of a standard text; the subject reoriented from a philosophical point of view to atomic interpretations. $10.00

THE STORY OF CHEMISTRY

By George Lockemann—A completely new, comprehensive history which not only includes the newest advances in nuclear chemistry but illumines ancient theories. $4.75

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By Kurt Walter—A handy review book for all students and for those who use mathematics in their work. Illustrated. $3.75

ATOMIC TERMINOLOGY

Edited by Lore Lettenmeyer—A dictionary of essential terms in atomic and nuclear physics and associated fields. English-German-French-Italian. $6.00

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By Frank Gaynor—A dictionary of standard and new terms in mathematics, physics, nucleonics, chemistry and geology. $10.00

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DICTIONARY OF ASTRONOMY AND ASTRONAUTICS

By Armand Spitz—Concise definitions of more than 2,200 terms and concepts, including those new to the space age. $6.00

THE CHALLENGE OF SCIENCE EDUCATION

Edited by Joseph S. Roucek and Howard B. Jacobson—A systematic survey and evaluation of the conflicting opinions on science education, by 34 distinguished experts. $10.00

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FSA Activities

FSA Inauguration

The enrollment of school chapters is now under way and is scheduled to hit a peak during the week of October 15-22. The FSA inauguration event coincides with the October theme—Science Youth Month.

No school or group need delay in joining in this vital program for youth. Anyone interested can write today to obtain application blanks from NSTA headquarters. Complete information and application forms were mailed recently on the FSA Informational Flyer describing the program. Additional copies may be obtained upon request. The program was initially announced in the September issue of *TST*.

One of the pioneering chapters will be issued to each of the first fifty who submit completed application forms, together with the necessary fees. These applicants will be identified as "Inaugural Chapters" of FSA.

As an example of the FSA presentation ceremonies, arrangements have been completed for the installation of an "Inaugural Chapter" at the Laboratory High School of the University of Iowa, Iowa City. Dr. James A. Van Allen, the noted physcist, and Dr. Robert E. Yager, head of the school's science department, will accept the charter. The enrollment of FSA chapters will continue throughout the year. Indications are that several hundred schools will enroll within this period. Sponsors of the chapters will receive a charter plaque, a *Sponsor's Guidebook*, and enough membership cards for the student members of the chapter. Other materials will be distributed on a continuing, supplemental basis.

Sponsor's Guidebook

The first edition of the *FSA Sponsor's Guidebook* is off the press. It should be a valuable source of ideas and tested suggestions for all sponsors. The twelve sections of the book are as follows: How to Start an FSA Chapter; Identification of the Science-Interested Student; Suggested Yearly Activities for FSA; How to Write a Scientific Paper; How to Produce Science Assemblies; How to Conduct a Science Forum; How to Organize a Science Seminar; The Whats, Whys, and Hows of Science Projects; Laboratory Assistants in the Classroom; Financial Assistance; FSA Chapters and Public Relations; and Suggestions for Working with Other FSA Chapters.

One copy of the first edition of the *FSA Sponsor's Guidebook* is included among the materials which each chapter receives for the charter fee. Additional copies may be obtained from FSA headquarters at $5 each. This price includes a supplementary service for one year.

FSAA, 1961

The Future Scientists of America Awards (FSAA) materials—information and entry forms—are now available to all teachers who have students interested to participate in the 1961 program. In accordance with recommendations made by the 1960 regional chairmen, the deadline date for entries this year will be *March 1, 1961*.

Regional chairmen have been appointed to assist in selecting the 198 students who will receive certificates and awards in 1961. The awards consist of U. S. savings bonds totaling $10,000. Entries must be based on projects done in any field of science or mathematics. All students in grades seven through twelve are eligible. In addition to the awards described, some 2000 students will receive FSA honorable mention certificates for meritorious achievement.

Past experience has demonstrated the importance of making an early start on projects to be reported in FSAA. Usually, two months or more may be required to do an investigative project or an extensive field study. Then there is the additional time required to do a careful job of writing the scientific report. It is strongly recommended that teachers help prospective FSAA entrants choose their projects and get them under way as soon as possible. The list of winners in 1960 and the titles of their projects may provide help in this vital first step. Single copies free from FSA headquarters *while the supply lasts.*

FSA Steering Committee

Consistent with NSTA policy to keep Association projects under surveillance of the membership, Robert A. Rice, President of the NSTA, has named a steering committee to work directly with staff in further development of the FSA program. Those who will serve during 1960-61 are: Anne E. Nesbit, South Junior High School, Pittsfield, Massachusetts; William V. Brook, 1571 Sixth Avenue, Huntington 1, West Virginia; Richard S. Smith, Haverford Township Senior High School, Havertown, Pennsylvania; Kenneth B. Hobbs, Ohio Academy of Science, Columbus, Ohio; Robert H. Horn, Waynesboro High School, Waynesboro, Virginia; and Edward S. Beach, Jr., Prince George's County Public Schools, Upper Marlboro, Maryland, *Chairman.* This committee will welcome comments and suggestions from all who are participating in the FSA program this year. Write any member of the committee or the headquarters staff. The committee will, of course, be in close communication with the FSA Field Advisory Board, which now numbers approximately 200 persons from the 50 states.

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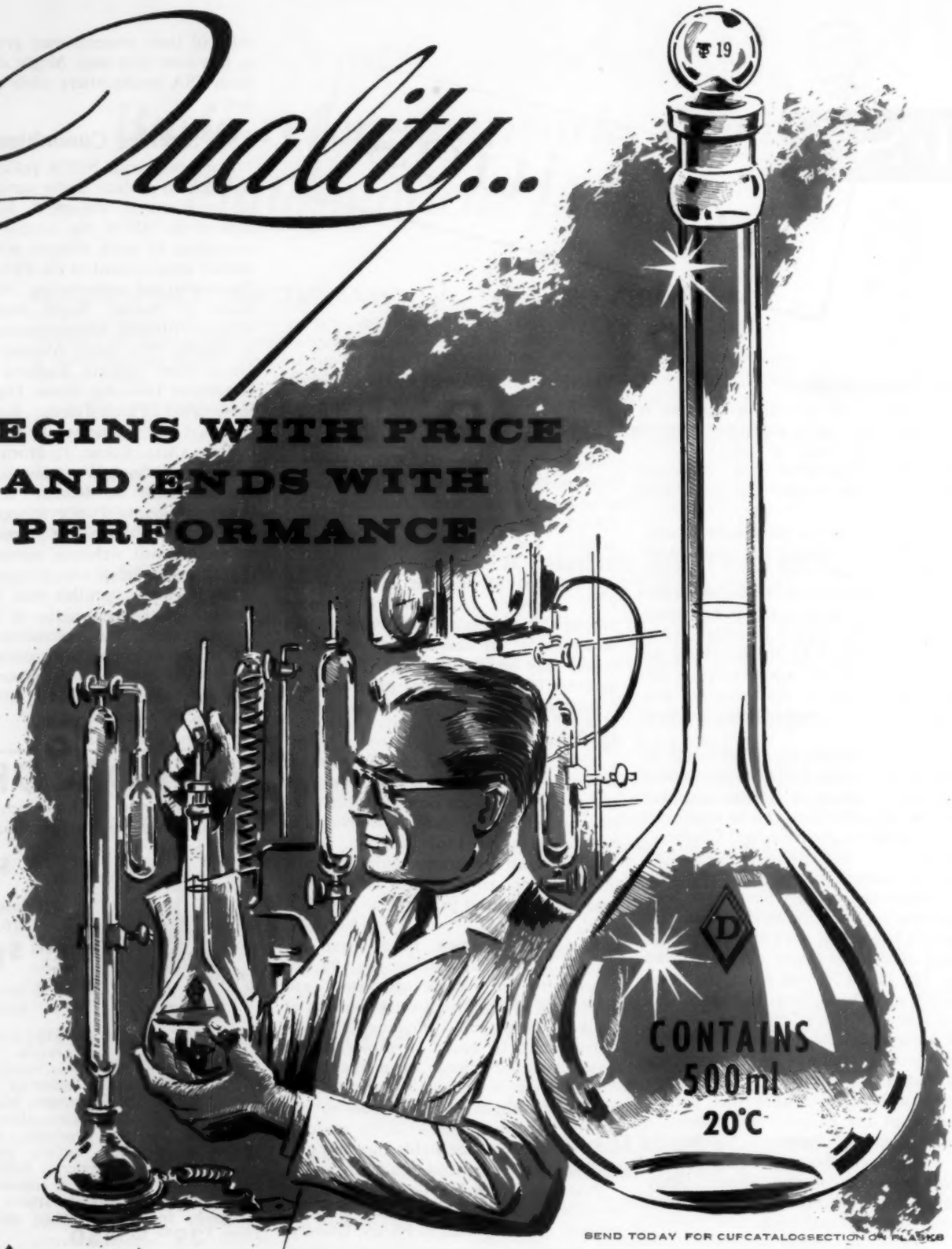

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BOOK BRIEFS

The Neutron Story. Donald J. Hughes. 158p. 95¢. Doubleday Anchor Books. Order from Wesleyan University Press, Inc., Columbus 16, Ohio. 1959.

The story of the neutron, written by an authority, giving the significance of neutron behavior in matter. Suitable for junior high and adult reader interested in the atom. Contains sketch drawings to illustrate text explanations. Takes the reader into advance aspects of neutron behavior in matter with emphasis on the atomic nucleus, atomic patterns, and the chain reaction.

Modern High School Chemistry. Edward F. Pierce. 110p. $1.50. Bureau of Publications, Teachers College, Columbia University, New York 27, N. Y. 1960.

This book is a well-produced outline for use in high school chemistry. The treatment of many individual topics is evidenced by thumbnail sketches of suggested courses. Technically, the publication is excellent and will assist in upgrading almost any course in high school chemistry.

Modern Physics. H. Clark Metcalfe, John E. Williams, and Charles E. Dull. 662p. $4.96. Henry Holt and Company, Inc., 383 Madison Ave., New York 17, N. Y. 1960.

Revision of 1955 edition by Dull, Metcalfe, and Brooks. Similar in style to previous edition. Introduces force and motion in second chapter. Uses British engineering and metric absolute units but expresses atmospheric pressure in grams per square centimeter. Introduces electron volt before defining volt. Contains more complete discussion of alternating currents and electronics. Tests and teacher's manual and answer book available.

Physical Science. Donald S. Allen and Richard J. Ordway. 826p. $8.25. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N. J. 1960.

This college-level physical science text has been written for the nonscience major with little or no background in science or mathematics beyond one year of algebra. Includes a relatively thorough discussion of a selected few topics in physics and chemistry, astronomy, meteorology, and geology, in that order. No attempt, however, is made to integrate astronomy and meteorology with physics and chemistry, although these disciplines are integrated with each other. Very general outlines for thirteen experiments appear at the end of the book. The main strength of the book is in the gradual introduction of algebraic concepts at increasingly mature levels to provide an understanding of physical principles in a semi-quantitative manner.

Modern Biology. Truman J. Moon, James H. Otto, and Albert Towle. 758p. $5.48. Henry Holt and Company, Inc., 383 Madison Ave., New York 17, N. Y. 1960.

A revised edition of a popular textbook in high school biology. Parts are reorganized and rewritten, with inclusions of new chapters on radiation and space biology. All areas of general biology are adequately covered. Color widely used in many fine illustrations. Accompanied by test book, teacher's manual and answer book, and a workbook and laboratory manual by Otto, Blanc, and Towle. These too have been revised from earlier editions so that they correlate with the new edition of the text.

Radioisotopes in Science and Industry. Special report of the U. S. Atomic Energy Commission. 176p. $1.25. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. January 1960.

The acceleration of the use of nuclear radiation and reactor by-products is the subject of this report. The major milestones are treated in isotope development, the uses of radioisotopes in agriculture and plant studies, medical diagnosis and therapy, and the utilization of isotopes in research, chemistry, and the life sciences. Sections on developments of new applications for using radioisotopes and safety programs make this report valuable to the science teacher who is planning to introduce laboratory

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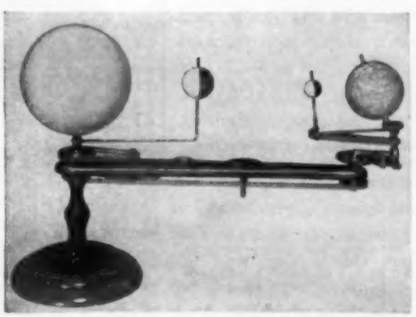

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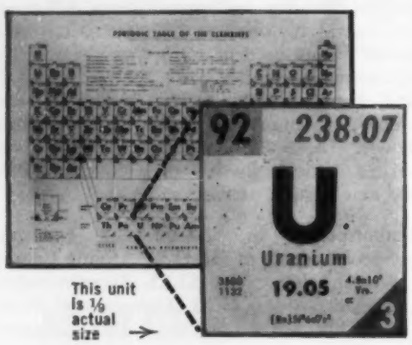

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Find a Career in Conservation. Jean Smith. 160p. $2.75. G. P. Putnam's Sons, 210 Madison Ave., New York 16, N. Y. 1959.

Young readers are introduced to an honest picture of the attractions—and the often-overlooked disadvantages—of the demanding but rewarding career in conservation. Descriptions in detail are given of the work of wardens, biologists, researchers, technicians, rangers, etc. The enthusiasm of the author offers a stimulus to the reader.

All About the Jungle. Armstrong Sperry. 142p. $1.95. Random House, Inc., 457 Madison Ave., New York 22, N. Y. 1959.

This is a treatment of the tropical rain forests of the world, including the Brazilian, Indonesian, and African jungles. Interesting examples of plant and animal life are described. Includes features of man's use of jungle resources and adaptation and survival in this habitat. Illustrated with drawings. Recommended for elementary and junior high ages.

Adventures in the World of Science. Charles Greeley Abbot. 150p. $3.50. Public Affairs Press, 419 New Jersey Ave., S.E., Washington 3, D. C. 1958.

This autobiography by an eminent astronomer and former secretary of the Smithsonian Institution is full of personal anecdotes about the lives of men prominent in science and statecraft in the first half of this century. It can enhance interest in the history of science and lend color to classroom teaching.

Born Alive. Erna Pinner. 196p. $3. Dodd, Mead & Company, 432 Fourth Ave., New York 16, N. Y. 1959.

Some of the fascinating aspects of natural history in this book will hold the reader entranced. Numerous documented accounts of the varied methods possessed by animals for continuation of the species and for caring for their young are presented in a style acceptable to the beginning, as well as the more advanced biologist. Discussions of polyembryogeny, sex-reversal, parthenogenesis, hermaphroditism, types of nests, and parasitism are examples of the topics that will intrigue the reader. An especially valuable work for high school biology students, but also suitable for college students and laymen.

Our Environment Science Series—Our Environment: Its Relation to Us. Paul E. Smith. 464p. $3.96. **Our Environment: How We Adapt Ourselves to It.** Paul E. Smith. 626p. $4.60. **Our Environment: How We Use and Control It.** Gordon E. Van Hooft. 688p. $5.68. Allyn and Bacon, Inc., 150 Tremont St., Boston 11, Mass. 1960.

This revision of Wood and Carpenter's *Our Environment* series combines its former successful teaching methods with new up-to-date subject matter and illustrations, and clear typography with a revision of its text material. Provides students with a general introduction to the sciences of physics, chemistry, and biology. Teaches them to organize factual matter and use it intelligently.

The Technical Institute in America. G. Ross Henninger. 276p. $6. McGraw-Hill Book Company, Inc., 330 West 42nd St., New York 36, N. Y. 1959.

A report of an extensive survey of the educational and employment practices of technical institutes. This important segment of our post-secondary educational system is engaged in training engineering technicians. Book will be of value to career counselors and science teachers.

Physics—An Exact Science. Harvey E. White, with the assistance of Eugene F. Peckman. 598p. $5.96. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N. J. 1959.

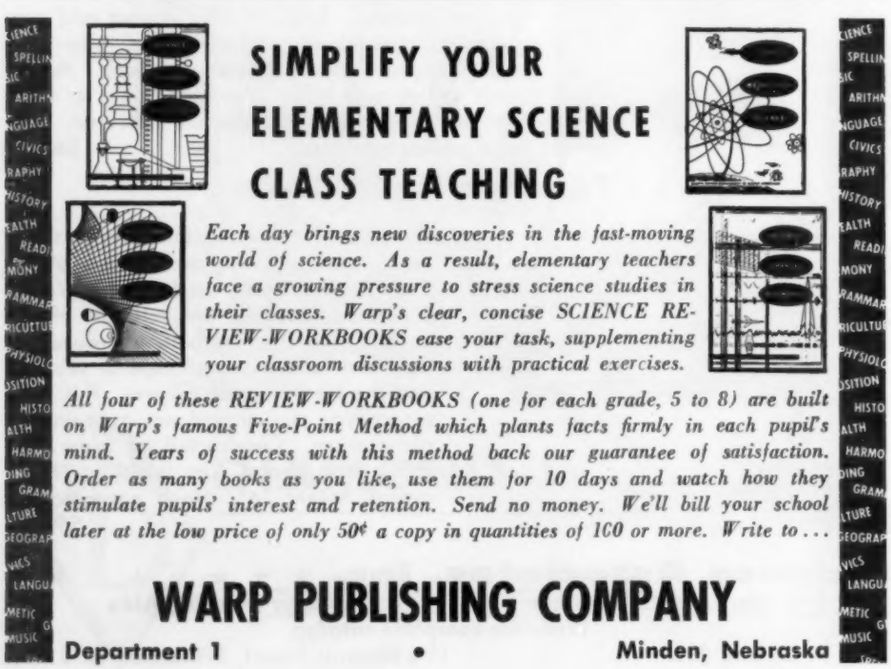
The lecturer in the well-known film series for high school physics has written this text intended for abler high school students. It is free of the usual errors, and the title succinctly describes the book. Puts strong emphasis on the topics of modern physics, devoting 28 lessons to atomic and nuclear physics, electronics, and quantum optics. Rules and definitions and statement of laws are printed in red for emphasis. Drawings also use red to emphasize important concepts.

Inside the Living Cell. J. A. V. Butler. 174p. $3.50. Basic Books, Inc., 59 Fourth Ave., New York 3, N. Y. 1959.

A vast amount of research on the living cell is concisely presented in understandable terms. Cell make-up, functional mechanisms, reactions to radiation, and transformation into malignancy are well presented. Appendices include selected references to more detailed works.

Louis Pasteur. Madeleine P. Grant. 220p. $3.25. McGraw-Hill Book Company, Inc., 330 West 42nd St., New York 36, N. Y. 1959.

A fine portrayal of the life of Louis Pasteur, his education, scientific discoveries, sacrifices, and successes. Gives the reader an in-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sight to the man as a scientist, a family person, and a citizen of France. Ably describes his discoveries concerning hydrophobia, the silk worm, and French wine manufacture. Well written. Suitable as general reading, especially for adolescents and young adults. Illustrated.

Selected Readings in General Chemistry. William F. Kieffer and Robert K. Fitzgerel. 128p. $2. Chemical Education Publishing Company, 20th and Northampton Sts., Easton, Pa. 1959.

A collection of various topics appearing in the *Journal of Chemical Education* during the past three years. Includes new developments from the research laboratory, together with correlating theory, to provide background information for the chemistry teacher. Also included are descriptions of laboratory experiments and teaching techniques which may be profitably used by the teacher of chemistry.

Magnets: The Education of a Physicist. Francis Bitter. 156p. 95¢. Doubleday Anchor Books. Order from Wesleyan University Press, Inc., Columbus 16, Ohio. 1959.

The story of magnets as portrayed through the experiences of the author. Includes description of the properties of magnets, relationship to electricity, magnetic properties of atoms and molecules, and the manufacture of magnets. Interestingly and factually written. Explores the advanced study of magnetism and its relationship to matter. Suitable for senior high school students, especially physics students.

Science Fun Book. Gerald M. Straight. 128p. $1. Hart Publishing Company, Inc., 74 Fifth Ave., New York 11, N. Y. 1959.

A book of science articles, biographies, experiments, facts, humor, puzzles, and quizzes. Suitable for boys and girls, especially 10-15 years old. Entertaining and useful in developing science interest among young people. Well illustrated.

Laboratory Performance Tests for General Physics. Haym Kruglak and Clifford N. Wall. 166p. Free to colleges and universities. Dr. Haym Kruglak, Western Michigan University, Kalamazoo, Mich. 1959.

The National Science Foundation has sponsored the publication and distribution of this book which includes performance tests in physics involving actual laboratory apparatus. In looseleaf notebook form.

Young Scientist Takes a Walk. George Barr. 160p. $3. Whittlesey House, McGraw-Hill Book Company, Inc., 330 West 42nd St., New York 36, N. Y. 1959.

A simple and interestingly written book explaining objects and natural phenomena found in the everyday environment of a child. Contains brief, well-illustrated, and accurate information on sounds, odors, building stones, sidewalks, the sky, insects, and

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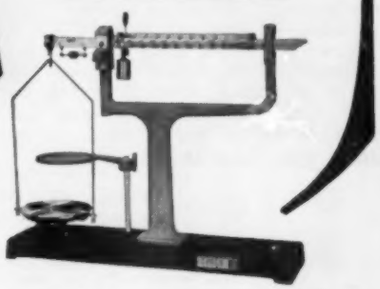

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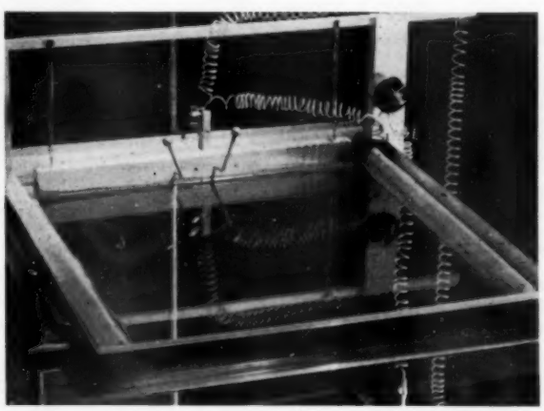

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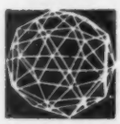

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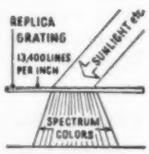

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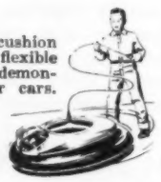

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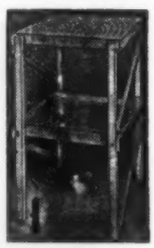

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other items. Many good suggestions and references for further study by children. Recommended as supplementary reading material for fourth and fifth grades.

Rockets into Space. Alexander L. Crosby and Nancy Larrick. 84p. $1.95. Random House, Inc., 457 Madison Ave., New York 22, N. Y. 1959.

Problems of space travel, with excellent illustrations of various stages of rockets and rocket development which catch the reader's interest. Material is presented in a well-organized fashion and explains itself well. The authors look into the future and give reasons for space exploration and its importance to mankind in our world today. An "Easy-to-Read Book" for children.

Atomic Radiation (Part 2). 118p. $2.65. RCA Service Company, 217 Highland Ave., Westmont, N. J. 1960.

Gives techniques for protection, monitoring, decontamination, material transport, and waste disposal. Useful in military and industrial applications and for civil defense training.

The Modern Slide Rule. Stefan Rudolf. 70p. $5. William-Frederick Press, 391 East 149th St., New York 55, N. Y. 1959.

A manual which provides a new method for using the slide rule, permitting exact fixing of the decimal point in the result. Includes many practice calculations. Useful as a supplement to instructions provided by slide rule manufacturers.

PROFESSIONAL READING

"Soviet Physics." *Physics Today*, 13:32. June 1960. A review of recent research by Russian physicists in the areas of field theory, nuclear reactions, ferromagnetism, and superconductivity is described in this article. An exhaustive treatment of the scope of Soviet research in physics is not included, and the article gives references to other publications where the more technical aspects are discussed.

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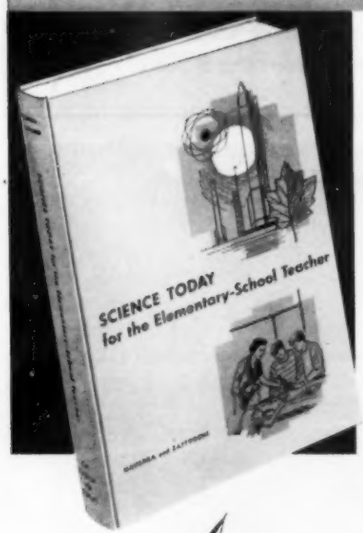

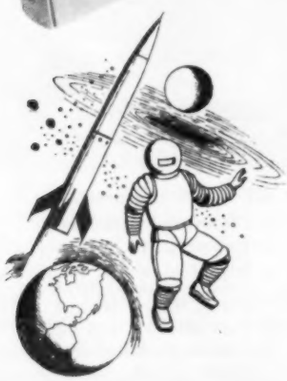

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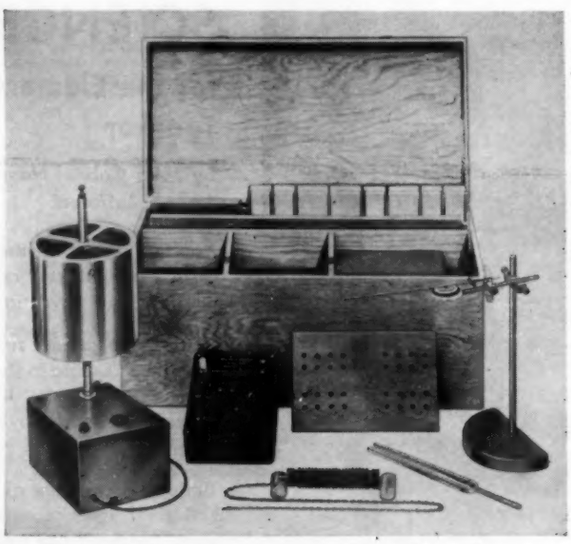

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"Humphrey Davy." By L. Pearce Williams. *Scientific American,* 202:106. June 1960. The author gives a thorough treatment of the life and accomplishments of the discoverer of sodium. Davy is also remembered as the sponsor of Michael Faraday who was his laboratory assistant. Diagrams of Davy's original apparatus and his laboratories are shown.

"Molon—A New Concentration Unit." By R. J. Gillespie and C. Solomons. *Journal of Chemical Education,* 37:202. April 1960. The symbol *W,* derived from weight concentration, and the name *molon,* derived from mole/kg of solution, are suggested as new terms to be used in describing the concentration of a solution.

"Are High School Chemistry Texts Up-to-Date?" By Donald B. Summers. *Journal of Chemical Education,* 37:263. May 1960. The material found in present texts is compared on a percentage basis with that covered in current high school courses of chemistry. The author discusses topics that are often poorly explained or neglected in high school chemistry texts, and gives reasons why alternate approaches should be used.

"Closed-Circuit Television as a Supplement to the General Chemistry Program." *Journal of Chemical Education,* 37:256. May 1960. The use of closed-circuit television is evaluated in the article as an actual teaching supplement. The Case Institute, for instance, used closed-circuit TV in a class in general chemistry and found that the student reception was excellent; the only drawback was the expense of such a production. The selection was informative, interesting, and well written. This article is recommended as a brief resume of up-to-date information on the practical application of a controversial new aspect of education.

"Laboratory by Discussion." By Rubin Battino. *Journal of Chemical Education,* 37:257. May 1960. The use of laboratory manuals in chemistry has been a subject generally opened with varied views and opinions. The process proposed in this article represents considerable improvement over the so-called "cook book" method of teaching in a chemistry laboratory. The author does not condemn the methods previously used without offering new ones which he considers to have many advantages and values in science teaching. Whatever views a reader may have in this area, he will find this informative article stimulating.

"The Exploration of the Moon." By Robert Jastrow. *Scientific American,* 5:61. May 1960. The surface of the moon, lacking an erosive atmosphere, is in a condition to reveal much about the history of the solar system. Cameras mounted on space craft will soon provide much information. After that, seismometers for reporting on moonquakes, gravimeters for measuring small changes in gravity, gamma-ray spectrometers, and other instruments can continue the explorations by remote control

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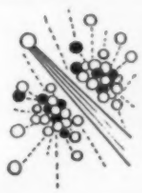

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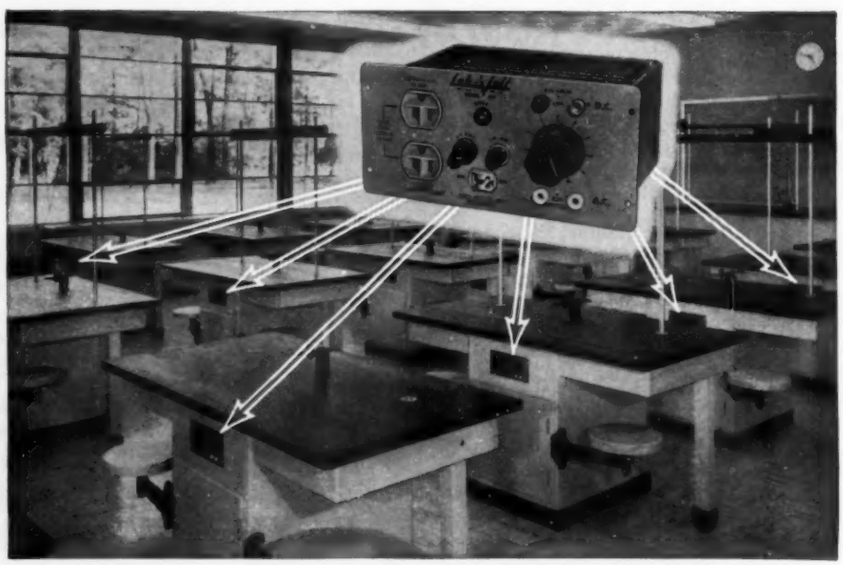

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The Spruce Bog. The National Film Board of Canada has produced an excellent story of the ecology of a bog in the boreal forest region of Canada. The entire successional sequence from open lake to spruce forest is vividly portrayed. Aerial photography of various stages gives a view seldom seen by students or teachers. Animals and plants associated with bog habitats are shown in beautiful photography. For high school or college classes. 23 min. Color $250. 1959. McGraw-Hill Text Films, 330 West 42nd St., New York 36, N. Y.

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Journey into Spring. The use of this British film in American schools can help to demonstrate many interesting facts about nature. One important understanding gained by an American high school student might be that niches in various parts of the world are similar and are filled by similar forms. The film does an excellent job of telling what might be considered a natural story although some of the commentary may be a little too poetic. Film setting is Hampshire, England, the parish of the famous eighteenth-century naturalist, the Reverend Gilbert White. Considerable ecology is included. For grades 9-12. 30 min. Color $250. 1960. Contemporary Films, Inc., 267 West 25th St., New York 1, N. Y.

To Smoke or Not to Smoke? The American Cancer Society has prepared another vital and objective teaching aid for use in secondary schools in any course concerned with health problems. This filmstrip presents results of research studies that show the relationship between cigarette smoking and lung cancer and explains how injurious substances in cigarettes affect normal functions of the lungs. No captions are included, but filmstrip is accompanied by a 15-minute recording of the explanatory text and also a teacher's guide. 84 frames. Color. Free.

As a regular feature of *The Science Teacher*, the calendar will list meetings or events of interest to science teachers which are national or regional in scope. Send your dates to *TST*'s calendar editor as early as possible.

October 28-30, 1960: NSTA Regional Conference, Deauville Hotel, Miami Beach, Florida

November 4-5, 1960: NSTA Regional Conference, Arizona State University, Tempe, Arizona

November 6-12, 1960: American Education Week. Theme: Strengthen Schools for the 60's

November 24-26, 1960: 60th Convention, Central Association of Science and Mathematics Teachers, Statler-Hilton Hotel, Detroit, Michigan

December 26-30, 1960: NSTA Annual Winter Meeting in conjunction with 127th meeting of the American Association for the Advancement of Science, the Commodore and Biltmore Hotels, New York City

February 1-4, 1961: Annual Meeting, American Association of Physics Teachers, Hotel New Yorker, New York City

February 22-25, 1961: 34th Annual Meeting, National Association for Research in Science Teaching, Pick-Congress Hotel, Chicago, Illinois

March 25-29, 1961: NSTA Ninth Annual National Convention, Hotel Sherman, Chicago, Illinois

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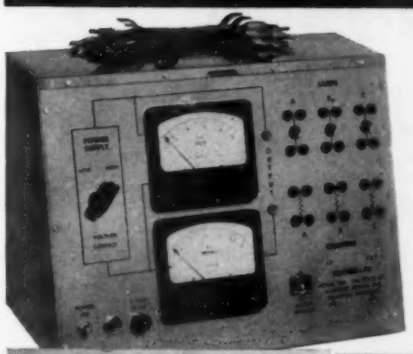

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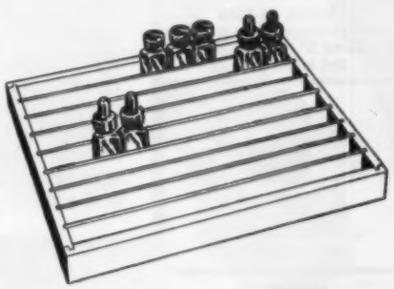

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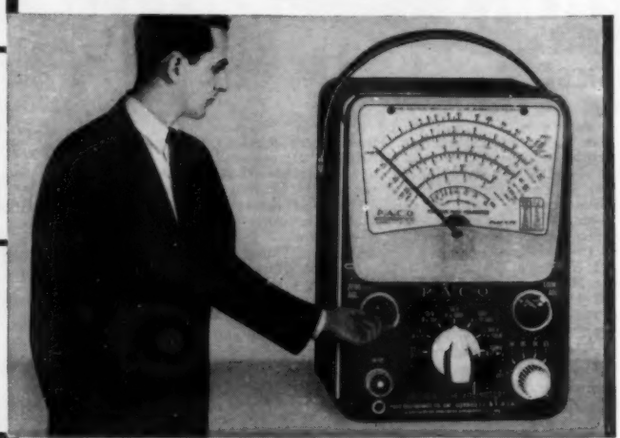

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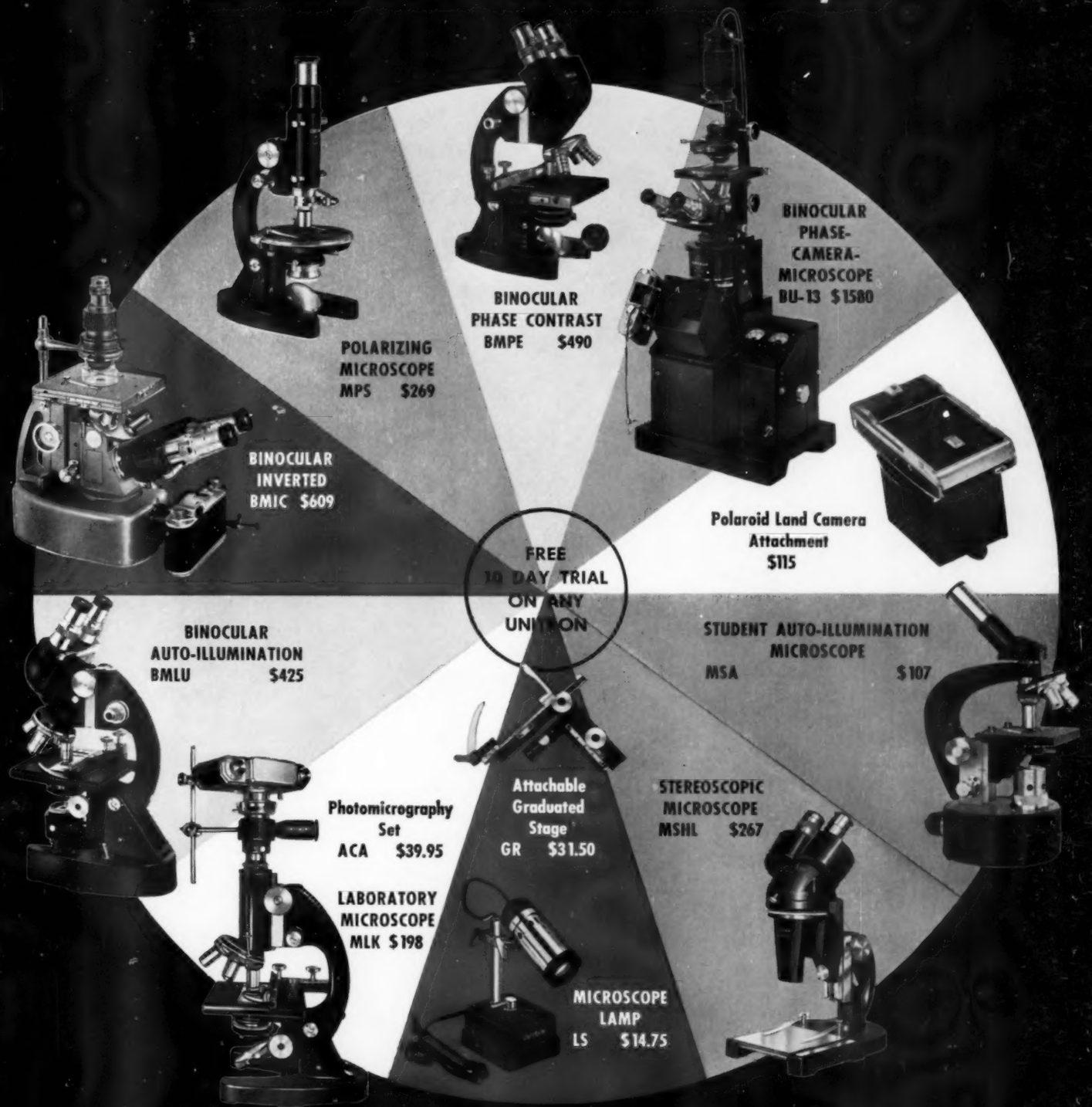
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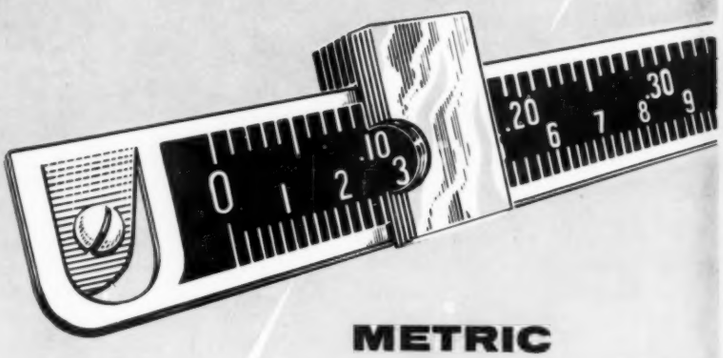

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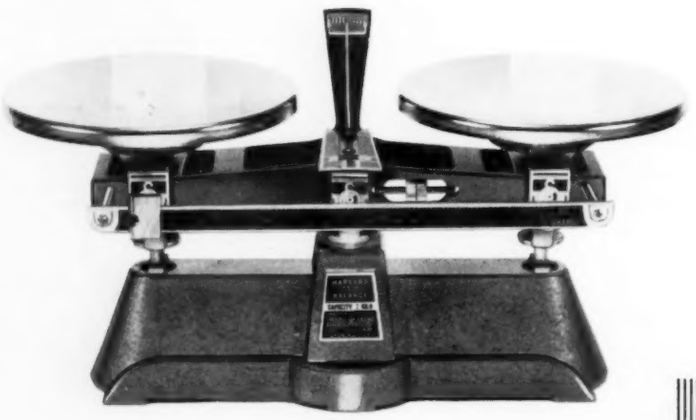

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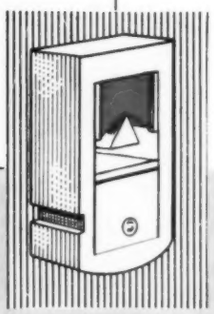

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